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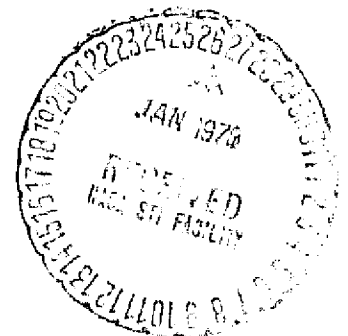
Volume IV: Network Design Software User's Guide

Prepared for

Law Enforcement Assistance Administration,
Department of Justice

by

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California



JPL PUBLICATION 77-53, VOLUME IV

**State Criminal Justice
Telecommunications
(STACOM)
Final Report**

**Volume IV: Network Design Software
User's Guide**

Jun-Ji Lee

October 31, 1977

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**Law Enforcement Assistance Administration,
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Prepared by the Jet Propulsion Laboratory,
California Institute of Technology, for the
Law Enforcement Assistance Administra-
tion, Department of Justice, by agreement
with the National Aeronautics and Space
Administration.

FOREWORD

The State Criminal Justice Telecommunications (STACOM) Project consists of two major study tasks. The first entails a study of criminal justice telecommunication system user requirements and system traffic requirements through the year 1985. The second investigates the least cost network alternatives to meet these specified traffic requirements.

Major documentation of the STACOM Project is organized in four volumes as follows:

State Criminal Justice Telecommunications (STACOM) Final Report - Volume I: Executive Summary	77-53 Vol. I
State Criminal Justice Telecommunications (STACOM) Final Report - Volume II: Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network	77-53 Vol. II
State Criminal Justice Telecommunications (STACOM) Final Report - Volume III: Requirements Analysis and Design of Texas Criminal Justice Telecommunications Network	77-53 Vol. III
State Criminal Justice Telecommunications (STACOM) Final Report - Volume IV: Network Design Software Users' Guide	77-53 Vol. IV

The above material is also organized in an additional four volumes which provide a slightly different reader orientation as follows:

<u>Title</u>	<u>Document No.</u>
State Criminal Justice Telecommunications (STACOM) Functional Requirements - State of Ohio	5030-43*
State Criminal Justice Telecommunications (STACOM) Functional Requirements - State of Texas	5030-61*
State Criminal Justice Telecommunications (STACOM) User Requirements Analysis	5030-80*
State Criminal Justice Telecommunications (STACOM) Network Design and Performance Analysis Techniques	5030-99*

*Jet Propulsion Laboratory internal document.

This document, No. 77-53, Volume IV, entitled, "Network Design Software Users' Guide," describes techniques that are implemented in the STACOM program. It then illustrates the application of this program by providing a run example with detailed input/output listing.

It presents the results of one phase of research carried out jointly by the Jet Propulsion Laboratory, California Institute of Technology, and the States of Texas and Ohio. The project is sponsored by the Law Enforcement Assistance Administration, Department of Justice, through the National Aeronautics and Space Administration (Contract NAS7-100).

ABSTRACT

A users' guide is provided in this volume for the network design software developed during the State Criminal Justice Telecommunications (STACOM) project sponsored by the Law Enforcement Assistance Administration (LEAA).

The network design program is written in FORTRAN V and implemented on a UNIVAC 1108 computer under the EXEC-8 operating system which enables the user to construct least-cost network topologies for criminal justice digital telecommunications networks. A complete description of program features, inputs, processing logic, and outputs is presented. Also included is a sample run and a program listing.

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SECTION 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

The STACOM (STate Criminal Justice COMmunication) network topology program is a software tool which has been developed and utilized during the STACOM project. This Software Users' Guide provides:

- (1) A detailed description of the program, i.e., what it does and how it does it.
- (2) Details of the STACOM storage structure and of its program structure so that a user can easily comprehend its capabilities and limitations.
- (3) Details of the options available, a functional block diagram, and a program listing with comment statements so that a user can expand/improve the program capabilities by either changing parameter values or modifying the program itself.
- (4) Details of a sample run stream used as a reference run for correct operation, and an input/output example, so that a user can easily operate the program as a tool for network design.

The STACOM program was developed and implemented with the FORTRAN-V programming language, which is one of several high-level languages available in the UNIVAC 1108 computer systems at the Jet Propulsion Laboratory. EXEC-8 is the operating system used in these systems. With this in mind, usage of this program in a similar UNIVAC system may require some degree of conversion effort. For a facility with computers other than the UNIVAC type, a considerable effort would be required in converting this program into one compatible with the operating system of that facility.

The balance of this document consists essentially of two parts. The first deals with the functional design portion of the STACOM topology program (Section 2); the other is concerned with the operational aspect (Section 3).

1.2 SUMMARY

1.2.1 The STACOM Program

The development of the STACOM (STate Criminal Justice COMmunication) network topology program was performed to support the primary STACOM objective of providing the tools needed for designing and evaluating intrastate communication networks. The STACOM project goals are to:

- (1) Develop and document techniques for intrastate traffic measurement, analysis of measured data, and prediction of traffic growth.
- (2) Develop and document techniques for intrastate network design, performance analysis, modeling, and simulation.
- (3) Illustrate applications of network design and analysis techniques to typical existing network configurations and new or improved configurations.
- (4) Develop and illustrate a methodology for establishing priorities for cost-effective expenditures to improve capabilities in deficient areas.

A task involving the development of a software package for the synthesis and analysis of alternate network topologies was undertaken.

In the following subsections, we describe a typical law enforcement communication network, what the STACOM program does, how it does it, and a general operating procedure for using the program.

1.2.2 State Criminal Justice Communication Network and its Optimization

A State law enforcement communication network is defined as a network which contains a set of system terminations connected by a set of links. Each system termination consists of one or more physical terminals or computers located at the same city, called a terminal city. The main purpose of the communication network is to provide to the terminal users rapid access to and response from the data base system, and rapid response time for intra-agency communication.

Various ways of connecting a given set of terminals may be used, depending on different requirements. Because the operating costs for a given communication network depend very much on its layout, some cost reduction is possible through an initial investment in a configuration analysis.

The activity of designing a network with the lowest costs which satisfy loading requirements, called network optimization, uses various existing techniques which provide means for such purposes.

1.2.3 Functions Performed by the STACOM Program

The STACOM program is a software tool which has been developed to design optimal networks that will achieve lower operating costs. It utilizes a modified Esau-Williams technique to search for those direct links between system terminations and a regional switching center (RSC) which may be eliminated in order to reduce operating costs without impairing system performance. The RSC provides either a switching capability, a data base center, or both.

Inputs for the STACOM program contain data such as traffic, terminal locations, and functional requirements. The network may be divided into any number of desired regions in any given program run. Each region has a Regional Switching Center (RSC) which serves terminals in its region. RSCs are, finally, interconnected to form the complete network. Upon receipt of a complete set of input data, the STACOM program first performs the formation of regions and, if needed, the selection of RSCs. The program then builds a regional network in which only system terminations in the region are connected. The program subsequently optimizes the regional network for each region requested by the user.

The formation of regions is performed by the program on the basis of attempting to arrive at near-equal amounts of traffic for all regions. After finding the farthest unassigned system termination from the system centroid (a geographical center), the program starts formation of the first region by selecting unassigned system terminations close to this system termination until the total amount of traffic for that region is greater than a certain percentage (90% in this implementation) of the average regional traffic. The average regional traffic is simply the total network traffic divided by the number of desired regions. The same process is repeated by the program in forming the rest of the regions.

The selection of an RSC is based on the minimal traffic-distance product sum. In the selection process, each system termination is chosen as a trial RSC, and the sum of traffic-distance products is then calculated. The location of the system termination which provides the minimal sum is then selected as the RSC, although the location of the RSC for a given region may also be specified by the user. The optimization process consists of two basic steps, i.e., searching for lines whose elimination yields the best cost saving, and updating the network. The two steps are repeated until no further saving is possible.

Before performing network optimization, the STACOM program constructs an initial star network in which each system termination is directly connected to the regional center. It then starts the optimization process. At the termination of this process, a multidrop network is generally developed. In a multidrop network, some lines have more than one system termination; these are called multidrop lines.

When needed, the STACOM program will continue to form an optimized interregional network, which consists of inter-connections between regional centers.

The process for interregional network optimization involves the same two steps: searching and updating. However, the searching step is primarily to find the alternate route, for diverting traffic between two regional switching centers, that provides the best saving.

Based on the data provided, a successful run of the STACOM program generates a regular printer output and, if requested, a CalComp plot. The printer output contains data such as initial regional network and optimized network costs, assignments of system terminations, etc. The CalComp plot shows the geographical connections of the optimized network detailing multidrop line connections to all of the system terminations.

1.2.4 Operational Procedure

1.2.4.1 Initialization and Setup. When the STACOM program is executed from an 80-character/line demand terminal, an alternate file, 100, to be used as a printer output file, must be defined. Otherwise, all printout data will be directed to the terminal which will produce interleaving output. The file is defined by the statement @ASG,UP 100.

In addition to the redirection of output file destination, the user must direct the punch card file to a proper unit for a CalComp plotter. As an example, the statement @SYM,P PUNCH\$,G9PLTF will direct the punch card images to a CalComp plotter designated with G9PLTF.

1.2.4.2 Starting a Run.

1.2.4.2.1 Batch Mode. Following is a list of control statements required when running the STACOM program as a batch run:

```
@RUN run-ID, account-no., project-ID, SUP-time, pages/cards
@ASG,UP 100
@SYM,P PUNCH$,plotter-ID
@XQT file.STACOM
      (INPUT DATA)
@BRKPT 100
@FREE 100
@SYM 100,,printer-ID
@FIN
```

The RUN card gives the following information: designated run ID, user's account number, project-ID, expected SUP-time usage (sum of CPU time, I/O time, and control/execute request time), limited number of printer pages, and number of cards which may be generated from the run. Plotter-ID gives the logical ID of the CalComp pen plotter and file is the file which contains the absolute element of the STACOM program. Printer-ID gives the logical ID of the line printer. INPUT DATA as shown is the input data required. When all of these data items are in order and ready, the deck can be submitted to the operator for processing.

1.2.4.2.2 Demand Mode. If program execution is to be performed via a demand terminal, the user can converse interactively with the program. The user may also run the program as a batch job by havin all input data prepared and added after the @XQT statement.

Under the conversational mode, the user acts as a respondent who answers the requests for data made by the program. This mode of operation provides the user with an understanding of how the program is progressing. A user can very often terminate a run before a complete set of input data is given if he has some knowledge of the progress being made. This capability can prevent the user from an unnecessary waste of time. For example, if a run encounters a system which has more oversized distance data than allowed, a message from the program will be printed out

on the terminal. This will force the user to modify the program in order to handle the large number of oversized distance data.

1.2.4.3 Normal Termination. When a STACOM program run proceeds successfully and terminates normally, the normal file unit 6 will contain messages for each successful regional network optimization. After a normal termination, the user can direct the output file 100 to a printer device, and the CalComp plot will be generated by the designated CalComp pen plotter.

1.2.5 Aborting and Recovering a Run

When a run encounters trouble resulting from incorrect input data, the user can use the normal aborting procedure to terminate its execution if it is a demand job. A statement of @@X after interrupting the line communication by pressing the BREAK key, will terminate a program execution at any time. On the other hand, the EXEC-8 may abort a run when certain serious violations occur during its execution.

If a program run has been interrupted because of a system outage, no recovery of the run is possible.

SECTION 2

THE STACOM PROGRAM

2.1 INTRODUCTION

Two types of analysis are involved in designing a communication network. The first is concerned with arriving at acceptable line loadings; the second involves the achievement of optimal line configurations. The STACOM program was developed to accomplish both of these types of analysis.

Before describing the STACOM program itself, a State criminal justice information system with its communication network is examined as a typical existing communication network. The goal of the STACOM program is then discussed.

2.1.1 State Criminal Justice Information System

An information system is usually developed to provide a systematic exchange of information between a group of organizations. The information system is used to accept (as inputs), store (in files or a data base), and display (as outputs) strings of symbols that are grouped in various ways. While an information system may exist without a digital computer, we will consider only systems which contain digital computers as integral parts.

Information systems can be classified in various ways for various purposes. If classification is by the type of service rendered, the type of information system which serves a criminal justice community within a State can be considered as an information storage and retrieval system. This type of information system is the subject of our interest. For example, the State of Ohio has an information system with a data base located at Columbus. The data base contains records on wanted persons, stolen vehicles, and stolen license plates. Also included in the same computer are files of the Bureau of Motor Vehicles (BMV) which contain records on all licensed drivers and motor vehicles in that State.

2.1.2 State Digital Communication Network

For a given State information system, the storage and retrieval of data to/from the data base can be accomplished in various ways for different user requirements. In general, the users of a State criminal justice information system are geographically distant from the central data base computer. Because a fast turn-around time is a necessity for this particular user community, direct in-line access to the central data base by each criminal justice agency constitutes the most important of the user's requirements. In addition, it is required to move message data quickly from one agency to another at a different location. These goals require the establishment of a data communication network. Because the computer deals only with digital data, only digital data communication networks are considered here.

A digital communication network consists mainly of a set of nodes connected by a set of links. The nodes may be computers, terminals, or other types of communication control units that are placed in various locations, and the links are the communication channels providing data paths between the nodes. These channels are usually private or switched lines that are leased from a common carrier. A simple example of a network is given in Figure 2-1, where the links between modems are communication lines leased from a common carrier. The communication control unit in city E is used to multiplex or concentrate several low-speed terminals onto a high-speed line. The line which connects cities C, D, and others is called a multidrop line, and this line connects several terminals to the data base computer.

2.1.3 A STACOM Communication Network

For the purposes of the STACOM study, a communication network was defined as a set of system terminations connected by a set of links. Each system termination consists of one or more physical terminals or computers located at the same city.

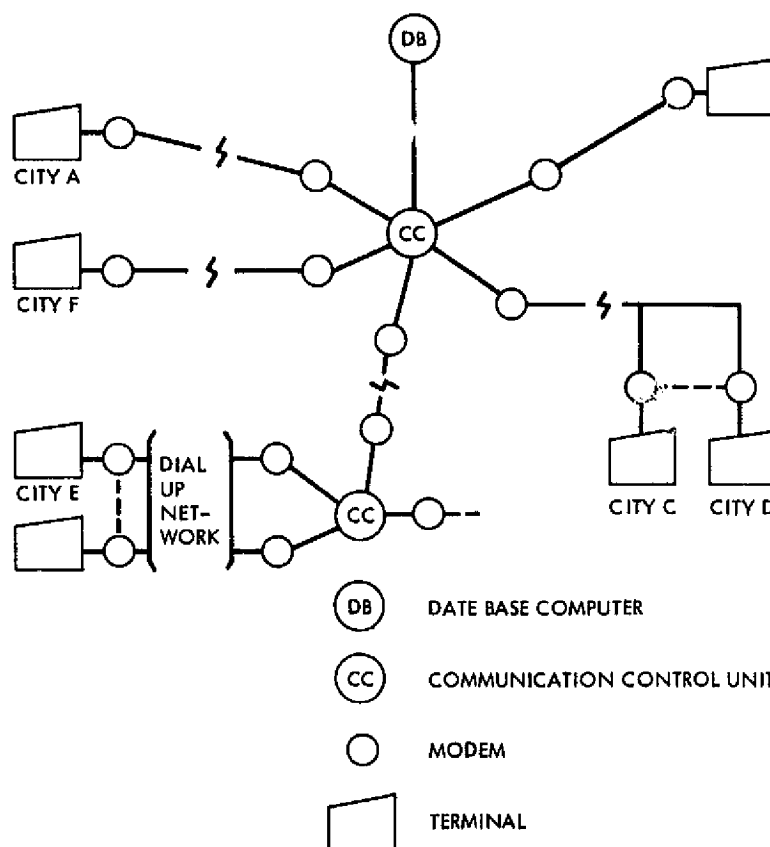


Figure 2-1. Example of a Digital Communication Network

2.1.4 Communication Network Configurations

The communication network for an information system with a central data base computer is one of three basic network configurations: the star, the multidrop, or distributed connection. These three types are shown in Figure 2-2.

As shown in Figure 2-2, the star network consists of four direct connections, one for each system termination. Each connection is called a central link. The multidrop network has one line with two system terminations and two central links. In the distributed network shown, more than one path exists between each individual system termination and the central data base.

2.1.5 Network Optimization

Given a communication network, the operating costs for the various types of lines or common carrier facilities required are governed by tariffs based upon location, circuit length, and type of line. Experience suggests that the operating cost of a network can often be substantially reduced by an initial investment in a configuration analysis. In other words, some efforts in network optimization generally provide cost-saving.

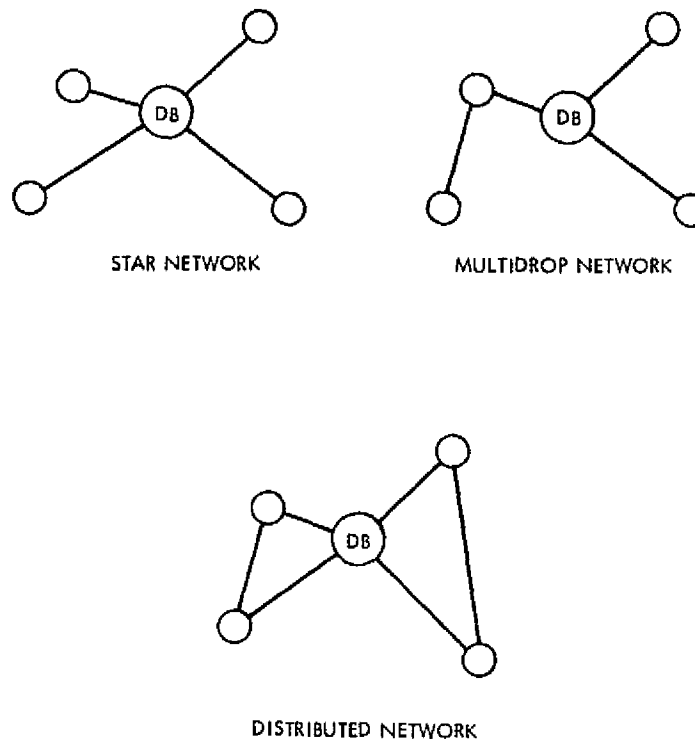


Figure 2-2. Basic Communication Network Configurations

There are two ways of constructing a communication network in a geometrical sense. One can divide a communication system into several regions, construct an optimal regional communication network for each region, and then build an inter-regional network connecting all of the regional centers to the central data base center. Each regional center is responsible for switching messages issued from and returned to each system termination in the region. Alternatively, one can consider the whole system as a region which is entirely made up of system terminations, and perform the optimization for that region.

2.1.6 The STACOM Program and its Purposes

One of the objectives in the STACOM study is to design optimal and effective communication networks which will satisfy predicted future traffic loads for both selected model states, Ohio and Texas. In order to achieve this objective, the STACOM program was developed and utilized for the analysis and synthesis of alternative network topologies. It is also the project's goal that the final product be a portable software package which can be used as a network design tool by any user.

In network design, two major problems are the selection of a cost-effective line configuration for given traffic, and the design of an optimal network to arrive at lower operating costs.

The goal of the STACOM program is to provide a user with a systematic method for solving both problems. In other words, the main purpose of the STACOM program is to provide the network designer with a tool which he can use for line selection and for obtaining optimal line connections.

2.1.7 Functions Performed by the STACOM Program

The STACOM program can be used to generate an optimal network configuration for a communication system if traffic to/from each system termination is provided. In addition to performing the normal input/output functions, the program will:

- (1) Define regions, based on equal traffic distribution.
- (2) Select regional centers, based on minimal traffic-distance product sum.
- (3) Form a regional star network with the selected regional center as the regional switching center (RSC).
- (4) Perform regional network optimization.
- (5) Form an optimized inter-regional network if required.

In performing initial network formation and subsequent optimization, line selection is done by the STACOM program to satisfy the following conditions:

- (1) The line utilization factor does not exceed a specific number
- (2) The average terminal-response time is less than a preselected unit of time
- (3) The number of terminals on a multidrop line is less than a preselected number.

In the process of regional network optimization, the STACOM program utilizes a modified Esau-Williams method (Reference 1). Starting with a star network, in which each system termination has a central link to the regional center, the optimization process searches for a central link, the elimination of which will provide the best savings in cost; the program then provides an alternate route for the traffic that would have been carried by the link eliminated. The process is repeated until no further cost saving is possible. The result of this process is a multidrop network.

When a communication system has more than two regions, the STACOM program can also be used to generate an optimal inter-regional network. It first constructs an initial inter-regional network in which every Regional Switching Center (RSC) has a direct link to every other RSC, it then performs line elimination by diverting traffic through other routes.

Figure 2-3 gives examples of regional star networks and an initial inter-regional network; Figure 2-4 gives examples of optimized regional networks and inter-regional network obtained from Figure 2-3.

2.2 MAIN FEATURES

As described in Paragraph 2.1, the STACOM program has been developed for the purpose of performing analysis and synthesis of alternative network topologies. The following is a list of features which characterize the STACOM program:

- (1) The Esau-Williams routine has been modified, tested and utilized for determining near optimal network topology.
- (2) A tree type structure is used as the storage structure in the program.
- (3) The program execution has been made flexible; for example, constraint on response time for a multidrop line is now an input parameter.
- (4) A response-time algorithm has been implemented in the program.
- (5) A CalComp plotting routine has been included for drawing resulting multidropped networks.

In the rest of this subsection, these main features are discussed in detail.

2.2.1 Structure

2.2.1.1 Storage. Since a multidrop network can be viewed as a tree composed of sub-trees, it was determined that a tree-type data structure would be appropriate and convenient for representing a multidrop network.

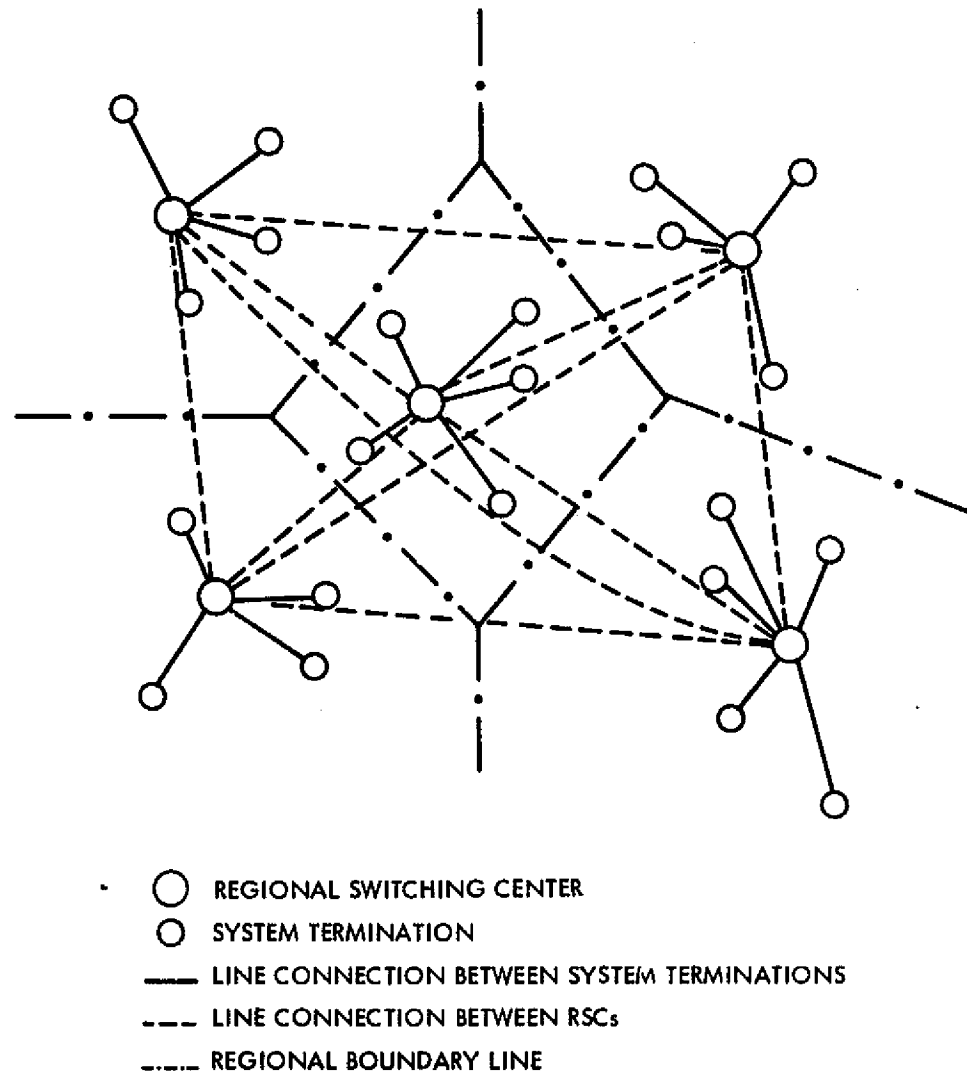


Figure 2-3. Example of Initial Regional Networks and an Initial Interregional Network

A tree-type storage structure is therefore needed in the program. This tree-type storage structure is implemented by defining a set of storage cells.

Each system termination (data) is represented internally by a storage cell in the program. Each cell consists of five fields and each field occupies one word (i.e., a 36-bit word for UNIVAC 1108 computers).

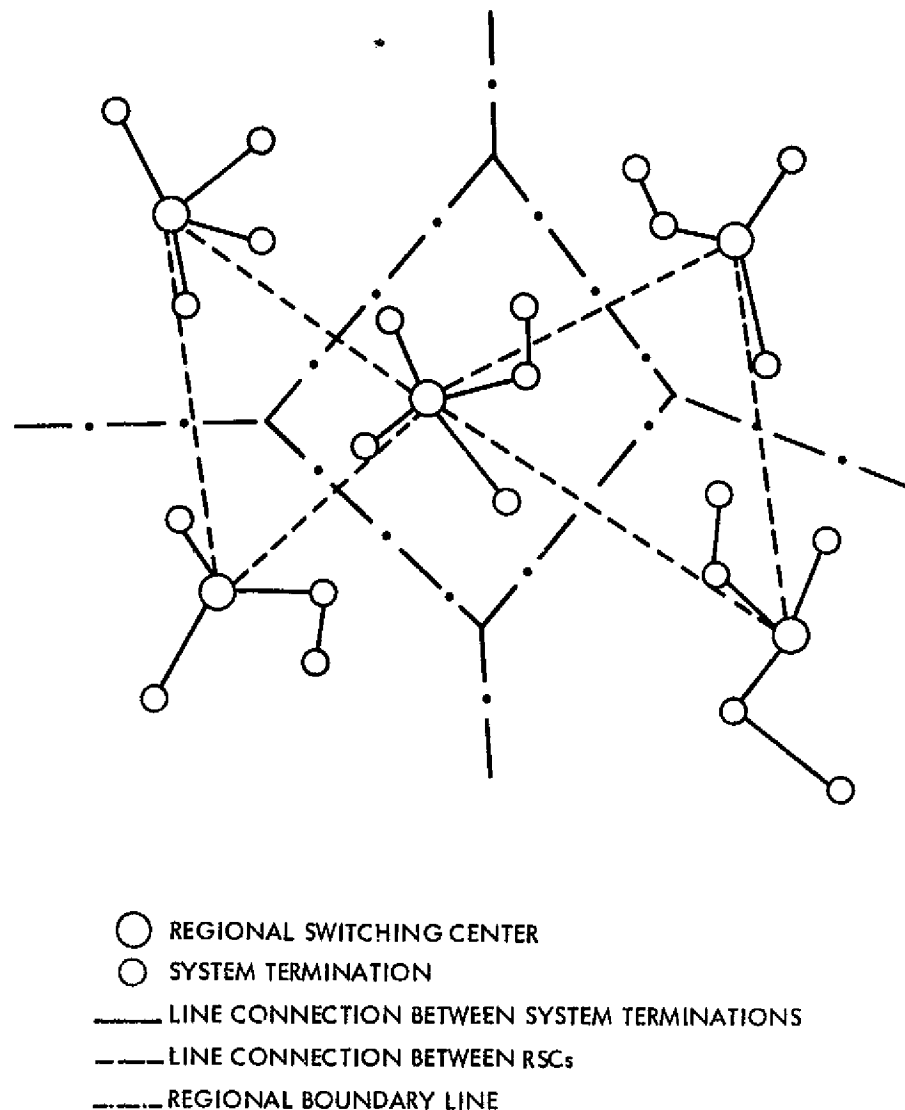
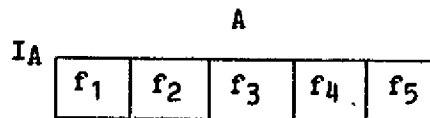


Figure 2-4. Example of Optimized Regional Networks and an Optimized Interregional Network

Defining that system termination X is a successor of Y and Y a predecessor of X if X branches out from Y, and X is the root of a tree if it has no predecessor before it, then the basic storage cell for system termination A can be described as follows:



Let $c(f_i)$ = content of i -th field in a storage cell I_A , where I_A is an internal index for a system termination A (data), then

$c(f_1)$ = the number of system terminations under A

$c(f_2)$ = a pointer which points to the first successor of A

$c(f_3)$ = a pointer which points to the next system termination whose predecessor is the same as A's

$c(f_4)$ = a pointer which points back to the previous system termination whose predecessor is the same as A's

$c(f_5)$ = a pointer which points to A's predecessor

When there is a 'zero' in a field, this indicates there is no one relating to A under that specific relationship. Given a tree as Figure 2-5, A is root of the tree; it has 4 successors, i.e., B, C, D, and E. Figure 2-6 is the internal representation of that relationship among indices I_A , I_B , I_C , I_D , and I_E which are internal cardinal numbers for system terminations A, B, C, D, and E.

The first field of storage cell I_A indicates that there are four system terminations under I_A ; the pointer to I_B says that I_B is its first successor. Since I_A is the root of the tree, the other three fields are left with zeros.

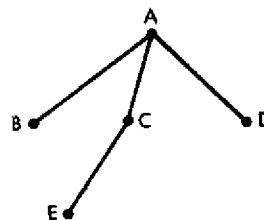


Figure 2-5. A Tree with A as its Root

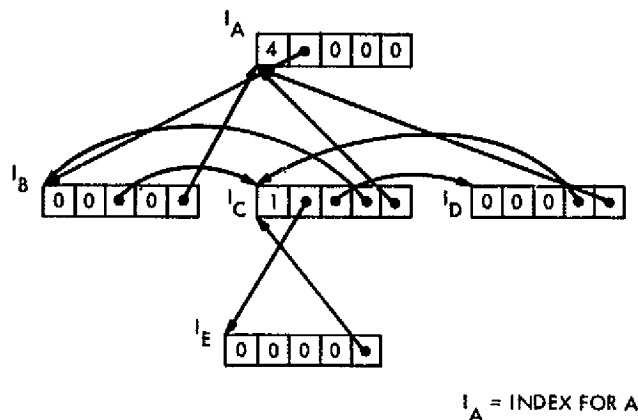


Figure 2-6. Internal Representation of the Tree
in Figure 2-5

In the case of I_C, I_D is the next successor of I_A and the previous successor of I_A is I_B. Its third field has a pointer pointing to I_D, and its fourth field a pointer pointing to I_B.

2.2.1.2 Program. The STACOM program consists of twelve functionally independent routines. Figure 2-7 shows the basic structure of the program. The functional interrelationship is indicated by arrows.

An arrow from routine A to routine B indicates that routine B will be called upon by routine A during its execution. All of these routines communicate to each other through the COMMON block in addition to the normal subroutine arguments.

Major functions of eleven of these routines are given below. RSPNSE Routine is described in the following paragraph.

(1) MAIN Routine

This is the master routine of the STACOM program. In its execution, it reads in all the data required from an input device (card reader or demand terminal) and performs calculations of distances between any two system terminations. It assigns system terminations to regions, and, if necessary, selects the regional switching center by finding the system termination in the region with the minimal traffic-distance product sum. It calls upon routine RGNNET to build a star network and then performs network optimization, if required, for each of these regions.

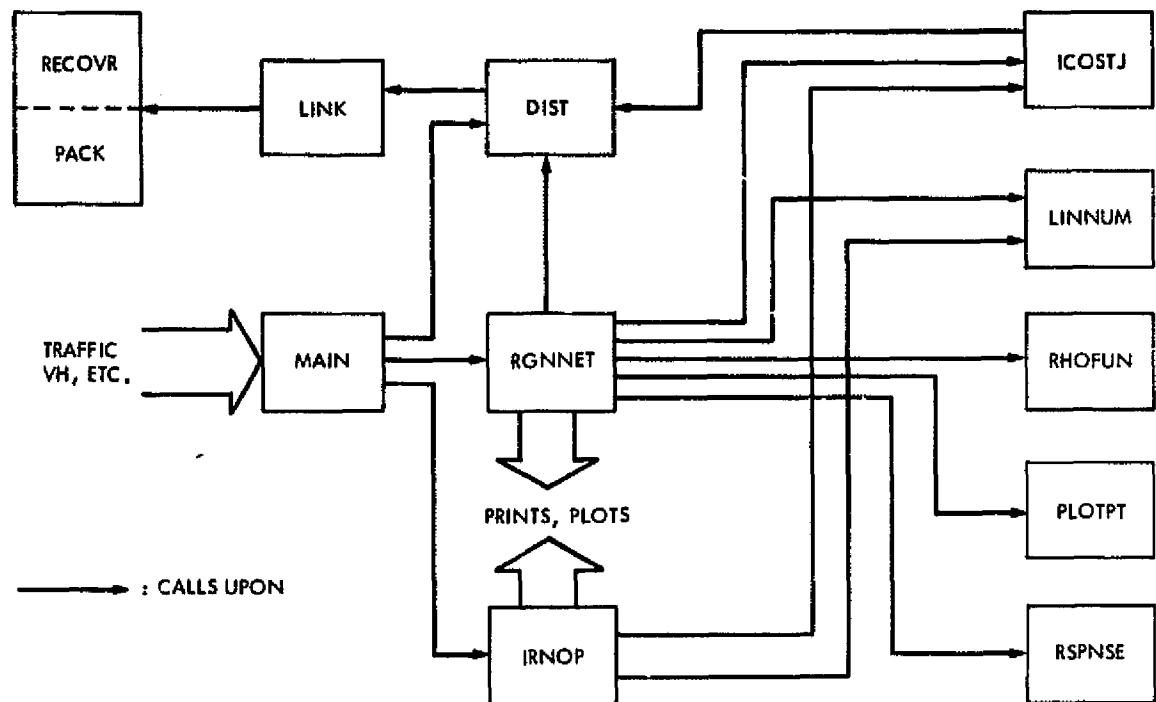


Figure 2-7. STACOM Program Structure

It also performs the construction of an inter-regional network and its optimization by calling subroutine IRNOP.

In addition to these processings, the MAIN routine also prints out distance matrix, traffic matrix, and lists of system terminations by region.

(2) RGNNET Routine

This routine is called upon only by the MAIN routine. Its main functions are the formation and optimization of regional star networks. During the formation of a regional star network, each system termination is linked directly to the designated or selected Regional Switching Center (RSC) by assigning the RSC index to the last field of each associated storage cell. Tree relationships are built among system terminations by assigning pointers to the third and fourth fields of each storage cell. The resulting star network is then printed on the printer.

The optimization process utilizes the Esau-Williams algorithm (Reference 1) with some modifications. It consists of two steps: searching for a central link (a direct link from a system termination to RSC) with best cost savings under constraints (such as response-time requirement), and subsequent network updating. This network optimization process is executed only upon request. When no further cost improvement is possible, this routine prints a resulting network with data such as number of system terminations and the response time, traffic, cost, etc., associated with each multidrop line. Routine PLOTPT is then called upon to plot the resulting network layout.

(3) IRNOP Routine

This routine is called upon to act by routine MAIN. It forms an interregional network and then performs its optimization. The interregional lines are assumed to be full-duplex lines. During the optimization process, no line between two RSCs can be eliminated if traffic between them cannot be handled through only one intermediate RSC. Also, each RSC requires at least two lines to other RSCs.

(4) LINNUM Routine

This routine provides an estimated line configuration required to satisfy a given traffic load and is mainly called upon by routine RGNNET. During its execution, utilization of selected lines are calculated against the given traffic load by calling RHOFUN so that effective line utilization is less than the pre-determined number.

(5) RHOFUN Routine

This routine calculates the line effective utilization for a given traffic and line configuration.

(6) ICOSTJ Routine

Given the line configuration and indices for any two system terminations, this routine calculates the installation costs and annual recurring costs for the line and other chargeable items required. In calculating line costs, it calls upon routine DIST for distance data between two given system terminations. Resulting cost data are arranged by chargeable item type.

(7) DIST Routine

This routine retrieves distance data between any two system terminations by calling routine PACK. When the

distance is greater than 510 miles, it retrieves distance data by calling routine RECOVER.

(8) PACK Routine

This routine stores or retrieves distance data between any two system terminations. It is called upon by routine MAIN for distance data depositing, and called upon by routine DIST for its retrieval. For the purpose of saving storage, distance data has been compressed, and each 36-bit word has been divided into four sub-words of 9 bits. Therefore, any distance datum with value equal to or greater than 511 is stored in another specified area; its retrieval calls upon routine RECOVER.

(9) RECOVER Routine

During distance data retrieval in the execution of the DIST routine, if the return value from routine PACK is 511, this routine will be called upon to provide the actual distance data, which is equal to or greater than 511.

(10) LINK Routine

Since the distance between any two system terminations I and J is independent of how I and J are referred to, the routine LINK provides a mechanism for preserving such an independency by mapping I and J into an absolute index.

(11) PLOTPT Routine

This routine provides instructions for plotting a given point on a CalComp plotter. Location of a point is calculated by its associated Vertical-Horizontal (V-H) coordinates (defined under Paragraph 2.4.2).

2.2.2 Response Time Algorithm -- RSPNSE Routine

There is a limit on the number of terminals which can be linked together by a multidrop line due to constraints on reliability and response time. However, it would be an oversimplification to just use a particular number as the main constraint in determining how many terminals a multidrop line can have. In reality, the response time of a given multidrop line depends on the amount of traffic, the number of terminals on the line, and very heavily, on the number of transactions to be processed in the data base computer system.

In the STACOM program, a response time algorithm is implemented in such a way that during the network optimization process it is used to accept or reject the addition of a given terminal to a multidrop line. This response time routine calculates the average response time

on the given multidrop line, given the number of terminals and amount of peak traffic on the line. This average response time accounts for the following types of delays; the wait-for-line time and line service time for the inquiry message from a terminal to the central switcher (i.e., a switcher which either contains data bases or communicates directly with the data base computer), the computer turnaround time at the switcher, and the wait-for line time and line service time for the returned message to the terminal. When there is an RSC between a terminal and the central switcher, the turnaround time at the RSC and the line service time between the RSC and the central switcher are counted as part of the average response time. Before its inclusion in the STACOM program, the fidelity of this algorithm was evaluated by simulation and found to be acceptable.

2.2.3 Flexibility

At the outset of the STACOM project it was anticipated that the STACOM program would be used for states with varying traffic requirements; it was decided that the resulting program should be as flexible and general as possible. With this in mind, the STACOM program has been implemented with the following features which make it flexible and thereby enhance its capabilities:

(1) Rate Structures, Line Types, and Chargeable Items

Because a State can have more than one rate structure (tariff) applicable at any one time, the STACOM program has been designed to accommodate this.

Under a specific rate structure, any combination of line types with their names, line capacities, and basic cost figures can be prescribed to the program. In addition to the line cost, any number of chargeable items associated with each line type can be prescribed to the program. For example, any combination of cost items such as service terminals, drops, modem and others can be used. Furthermore, under the Multischedule Private Line (MPL) tariffs given by AT&T for interstate communication lines, the monthly line charge between any two terminals is now a function of both the inter-city distance and the traffic densities of both terminal cities. The STACOM program has been implemented in such a way that it can take line-cost figures based on MPL tariffs or other tariffs.

(2) Region Formation, Switcher Selection, and Network Optimization.

Given a set of system terminations dividing them into regions can be performed in either of the following ways: the user can pre-assign some or all of the terminations into preselected regions, alternatively, the user can let the program perform the region

formation by simply providing the system centroid. Following the formation process, the STACOM program will start selecting regional switching centers for regions without a preassigned switching center. The process of regional network formation and its optimization will then follow.

(3) Number of Terminals per Multidrop Line.

It may be desirable to set a limit on the number of terminals on a multidrop line. In its implementation, the STACOM program takes this number from the user's input data as a constraint during its optimization process.

(4) Average Terminal Response Time.

Besides the limit on the number of terminals allowed on a multidrop line, a good network design also requires a constraint on the average terminal response time on a multidrop line. The STACOM program allows a user to specify the limit on a run basis.

2.2.4 Programming Language

The STACOM program is implemented with the FORTRAN V language of UNIVAC systems, compiled with the EXEC-8 FORTRAN processor, and mapped by its MAP processor.

Detailed features of FORTRAN V programming language are described in Reference 2.

2.2.5 Operating System Requirements

Because the EXEC-8 operating system of the UNIVAC 1108 computer was used in the development of the STACOM program, the current edition of the STACOM program can only be executed under the EXEC-8 system. Furthermore, since a CalComp routine is linked with the program, the plotter must be part of the operating system. If such a hardware unit is not included in the system, the STACOM program must be updated to reflect this environment.

In addition, the current STACOM program was designed with the feature that all the desired output be put into a FORTRAN file designated as 100. Before executing this program, a file with the name 100 must be assigned. Otherwise, regular WRITE unit 6 will be the destination output file, e.g., the print output will go the user's demand terminal when it is run as a demand job.

As an example, the following is a complete list of EXEC-8 control statements which need to be prepared or typed in after the run card for properly executing the STACOM program.

```

@ASG,UP 100
@SYM,P PUNCH$,,G9PLTF
@XQT File.STACOM

```

```

.
.
(data)
.
.

```

```

@BRKPT 100
@FREE 100
@SYM 100,,T4

```

The @SYM,P command directs the resulting plot card images to a CalComp plotter designated G9PLTF. The last @SYM command directs print output to a slow hardcopy printer designated T4.

2.2.6 Functional Limitations

While the STACOM program was designed and implemented with the intention that it be applicable as widely as possible, it does have certain limitations. These are due mainly to the limit of the program size (sum of I and D bank) allowed under the EXEC-8 system for simplistic programs. The maximum program size allowed is 65k words per program. Although it is more convenient for later use to assign all parameters with maximum values (as long as the overall program size is within the 65K-word limit) this results in greater expense in use of the program due to the higher core-time product. Therefore, it is recommended that all parameters be set at values just high enough for anticipated use.

After setting parameter values, the STACOM program capabilities are then limited to these assigned values. If a run requires that a certain parameter value be exceeded, the STACOM program must be recompiled and remapped.

2.3 INPUT

2.3.1 Data Requirements

A setup of input data is needed before starting a STACOM program run. The list of data items which need to be provided by the user are given here in temporal order and explained briefly. Detailed FORTRAN V formats for these are described in Table 3-1 of Section 3.

2.3.1.1 Number of Regions. The first datum needed by the STACOM program is the exact number of regions under consideration. This number (designated internally as NR1) instructs the program to divide all of the system terminations into NR1 regions.

2.3.1.2 Number of System Terminations, Number of Data Bases, and Number of Terminal Cities. The number of system terminations is the actual number of system terminations to be operated .n by the STACOM program, and is designated internally as N1. In anticipation of possible multiple data bases at different locations, the number of data bases (designated internally as N7) informs the program that each system termination has N7 pairs of data (one pair per data base).

The number of terminal cities (NCITY) informs the program that NCITY V-H coordinates are to be provided later.

2.3.1.3 Identification of Data Bases and V-H Coordinates. N7 identifications provides the exact locations of data bases under consideration. All of the V-H coordinates for NCITY terminal cities are needed for calculating distances between any two cities.

2.3.1.4 Descriptions of System Terminations. For each of the system terminations under consideration, the set of data, i.e., identification, name, city location index, and traffic to all of N7 data bases are needed in order to properly execute the STACOM program.

2.3.1.5 Rate Structure and its Application Rule. There may exist one or more line tariffs applicable to different portions of any given state. The STACOM program has been designed with a capability to handle this situation. The number of applicable rate structures (line tariffs) and the rule governing their applications have to be input to the program by the user.

2.3.1.6 Traffic Density and Applicable Rate Structure for each System Termination. In order to accommodate the fact that costs for lines between high traffic density cities are much lower than for others, (e.g., TELPAK lines), the traffic density index and applicable rate structure for each system termination informs and directs the program to properly perform costing on lines connected to this termination.

2.3.1.7 Descriptions of Applicable Lines. The user dictates to the STACOM program the types of applicable communication lines by providing number of lines, their names and capacities, their desired maximum utilizations and their uses.

2.3.1.8 Descriptions of Chargeable Items. In addition to costs for lines, there are several other chargeable items such as modems, service terminals and drop charges. The user must provide the number of chargeable items and their names. Furthermore, the user has to provide the STACOM program with installation and monthly recurring costs for each chargeable item as a function of rate structure, line type, traffic density, and duplexing mode. This costing information is required to estimate overall cost of the to-be-designed communication network.

2.3.1.9 Line Cost Data. Installation and monthly recurring costs for lines for each applicable line type as a function of rate structure, traffic density, and duplexing mode are also required.

2.3.1.10 Constraints on Formation of Regions. The user can preload any number of system terminations to preselected regions if so desired by assigning them to their specific destinations (regions). He can also put constraints on preselected regions by not allowing any insertion of system terminations to these regions.

2.3.1.11 Options on Regional Network Optimization. The user can direct the STACOM program to perform regional network optimization on regions if required. This is done by simply specifying such requests to the program.

2.3.1.12 Protocol Characteristics for Multidrop Lines. The user must provide characteristics of line protocol to the program. For example, characteristics such as number of polling characters, NAK response characters, and message overhead characters are required. These data, along with the other line traffic characteristics data, enable the STACOM program to estimate the average terminal response time for a given multidrop line.

2.3.1.13 Characteristics of Future Traffic. Characteristics for future line traffic are also required. Data such as number of message types, their ratios, and average lengths allow the program to compute line service time and line utilization, which, in turn, are used to estimate the average terminal response time.

2.3.1.14 Preloading System Terminations to Preselected Regions and Pre-Assigning Regional Switching Centers. If the user wishes to assign certain system terminations to preselected regions and to pre-assigned regional switching centers, he can now proceed to do so. Otherwise, the program will perform these functions automatically.

2.3.1.15 Assigning System Centroid. If the STACOM program is required to divide system terminations into regions and to select regional switching centers, the system centroid is required so that the program can divide them properly (in a geographical sense).

2.3.1.16 Descriptions of the Central Switcher. Data describing the central switcher are needed to compute switcher turn-around time for a given transaction. These data include the estimated message rate at the switcher, number of transactions entering the switcher for completing a message, average service time per transaction, and number of processors available.

2.3.1.17 Constraints on Multidropped Lines and Average System Response Time. The user can impose a constraint on the number of terminals allowed on a multidrop line either by limiting the number of terminals on a multidrop line, or by setting up a maximum average response time limit to the multidrop line or both.

2.3.1.18 CalComp Plot. The user can request a CalComp plot of the final multidrop communication network if so desired. Of course, some installations may not have such a device and the STACOM needs to be recompiled without plotting routine.

2.4 PROCESSING LOGIC

The previous section described the type of input data needed by the STACOM program. This subsection will be devoted to the processing logic implemented in the program.

2.4.1 Traffic Calculation

2.4.1.1 Traffic Conversion. In the STACOM program, each system termination is provided with a set of traffic figures which represent outgoing traffic to and incoming traffic from each data base in the system. The unit of traffic is specified as characters per minute.

The traffic data for all system terminations are read into the matrix TRAFD(N1, 2, N7) during the data input phase, where N1 is the number of system terminations and N7 is the number of data bases. While the input traffic data are given in characters per minute, the STACOM program is designed to deal with traffic in terms of bits per second (BPS). Thus, at the time of program execution, all traffic data are converted into units of bits per second by multiplying them by a factor of 8/60. Here, we assume that synchronous communication is to be used.

2.4.1.2 Origin and Destination Traffic by System Terminations. Summations across the last subscript of the TRAFD matrix are performed to give total traffic originating from and destined for each system termination. The resulting data are stored in TRAFIT (N1) and TRAFDN (N1), respectively. More specifically, originating and destination traffic totals are given by

$$\text{TRAFIT}(i) = \sum_{j=1}^{N7} \text{TRAFD}(i, 2, j)$$

and

$$\text{TRAFDN}(i) = \sum_{j=1}^{N7} \text{TRAFD}(i, 1, j)$$

2.4.2 Distance Calculation

2.4.2.1 V-H Coordinates. The length of the line plays a major role in determining line costs on communication networks. While the common carrier is free to route the line over any desired path, and may switch the line to different paths to circumnavigate breakdowns or overloads, the line charges are normally independent of actual line layout and are based on the straight line distance between the points connected.

The AT&T has a system in which they have divided the United States by horizontal and vertical grid lines. By means of these lines, they give almost every city/location a vertical (V) and horizontal (H) coordinate, these coordinates provide the layout-free way of distance calculation.

2.4.2.2 Distances between System Terminations. With V-H coordinates as defined by the AT&T, the distance between any two locations is calculated as follows (Reference 3):

- (1) Obtain the V and H coordinates for these two locations.
- (2) Obtain the difference between the V coordinates and the difference between the H coordinates of these two locations.
- (3) Square each difference obtained in 2 and take a summation of both squares.
- (4) Divide the sum obtained in 3 above by 10. Round to next integer number if any fraction is obtained.
- (5) Obtain the square root of the result obtained in 4 above. This is the distance between the given locations in miles. (fractional miles being considered as full miles.)

For example, to calculate the distance between Austin and Dallas, Texas, we proceed as follows:

	<u>V</u>	<u>H</u>
Austin	9005	3996
Dallas	8436	4034
Difference	569	38

$$\begin{aligned}
 \text{Distance} &= \sqrt{\frac{(569)^2 + (38)^2}{10}} = \sqrt{\frac{323761 + 1444}{10}} \\
 &= \sqrt{32521} = 181 \text{ miles}
 \end{aligned}$$

When a specific location in the United States is not designated with specific V and H coordinates, it is normally assigned with the same V and H coordinates as the closest location.

Following the procedures as given above, the distance between any given two system terminations is calculated and stored in arrays DSTNCE or IVRD.

2.4.2.3 Distance Data Compression and Overflow Table. Given N system terminations, there are $N(N-1)/2$ combinations in choosing two system terminations from them. Furthermore in any given state, there exist only a few large inter-terminal distances. These two facts indicate that some reduction in resulting STACOM program size can be made by performing compression of distance data. Two efforts have been undertaken for that purpose.

Under the UNIVAC system, each computer word is 36 bits long. We divide each word into four 9-bit segments. Each segment is used to store one distance datum with values ranging from 0 to 511. To compensate for the fact that some distances data may be greater than 511, an overflow table IVRD is provided to collect oversized distance data. In other words, given two system terminations with indices I and J, its distance is recorded into DSTNCE as follows:

- (1) Find corresponding V-H coordinates of locations for both system terminations.
- (2) Calculate distance D according to the procedure given in Paragraph 2.4.2.2.
- (3) Find a unique and absolute location L in DSTNCE, by using the following equation:

$$L = I * NPC + J - \Delta(I)$$

where

$$\Delta(I) = \sum_{i=1}^I i,$$

and

$$I < J$$

NPC = number of distinctive locations in the system

This mapping function is performed by subroutine LINK,

- (4) Define

$$L1 = [(L-1)/4] + 1$$

$$S1 = (L-1) \text{ Modulo } 4 + 1$$

where $[x]$ = the integer part of x and

$$D1 = D \text{ if } D < 511 \\ 511 \text{ if } D \geq 511$$

- (5) Store $D1$ in segment $S1$ of entry $L1$ of table $DSTNCE$.
- (6) If $D \geq 511$, store L and D in next available space of table $IVRD$.

On the other hand, given two system terminations with indices I and J , the retrieval of distance is performed as follows:

- (1) Calculate L , $L1$ and $S1$ as described above.
- (2) Retrieve the content $D1$ in segment $S1$ of entry $L1$ of table $DSTNCE$. If $D1 < 511$, it is the distance.
- (3) If $D1 = 511$, retrieve the second element of the row of table $IVRD$, whose first element contains value L . The retrieval value is the distance.

2.4.3 Formation of Regions

After traffic summations and distance table formation are completed, the STACOM program starts to form regions. It assigns all of the non-preloaded system terminations to regions which can accommodate them. Figure 2-8 illustrates the process of such a function.

The process begins with an estimation of the traffic per region, called TPR , which is obtained by averaging the total non-binding traffic, i.e.,

$$TPR = TPR1/ANR1$$

with

$$TPR1 = \sum_{\substack{i \in I \\ 1 \leq i \leq N1}} [TRAFIT(i) + TRAFDN(i)]$$

where

I = the set of system terminations in preloaded regions which do not allow other system terminations to be inserted to them

$ANR1 = NR1 - [\text{number of preloaded regions which do not allow any insertions}]$

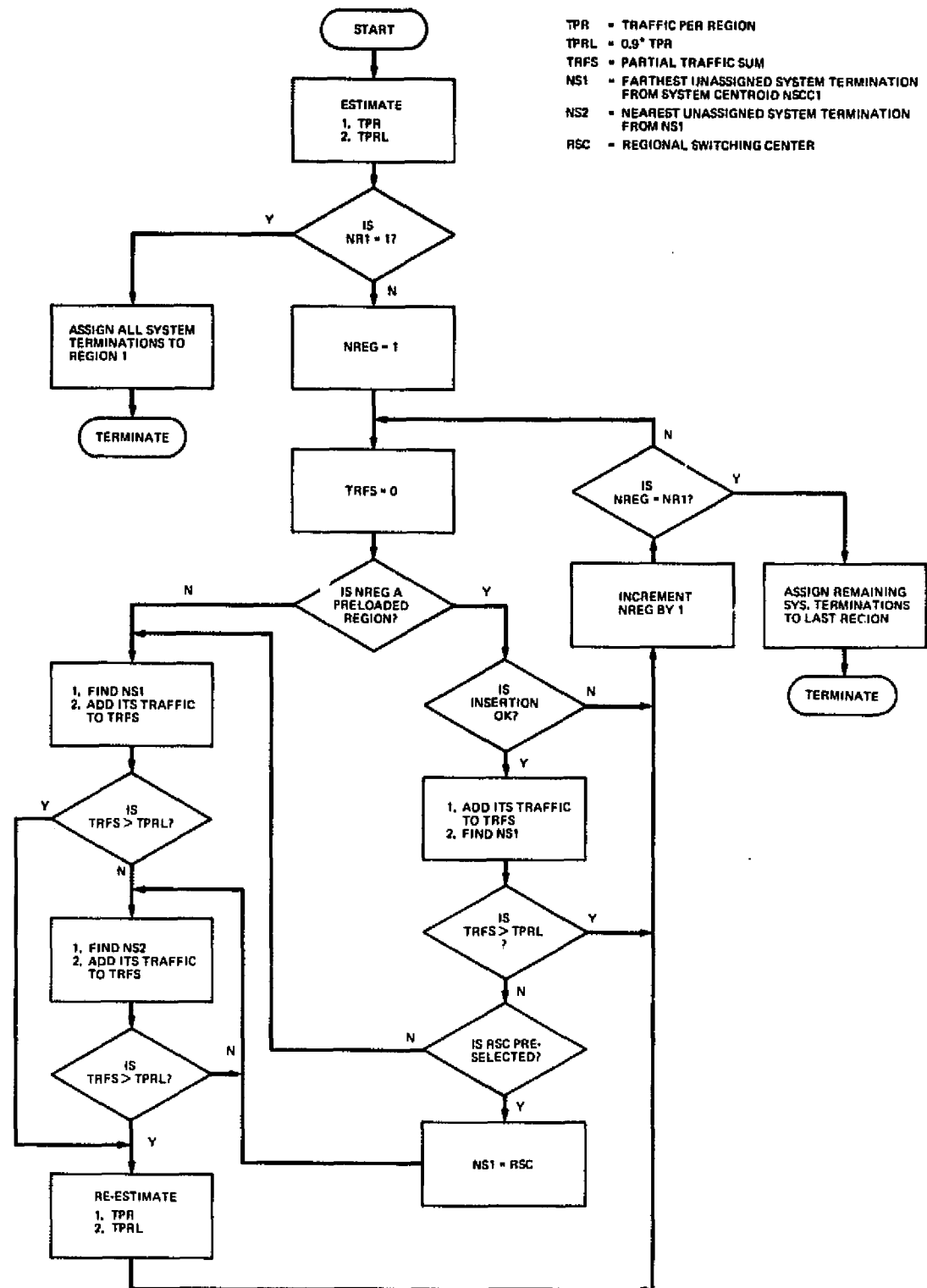


Figure 2-8. Flow Chart for Formations of Regions

When the number of regions is 1, all of the system terminations are assigned to the region and no other region formation process is performed. Otherwise, the program starts assigning system terminations to regions (in a cardinal order) which allow their entries.

The following two subsections describe the detailed processes for assigning system terminations to a region either with preloading or without preloading.

2.4.3.1 Assigning System Terminations to a Region without Preloading.

When a region NREG is not preloaded with any system termination, processing continues with the finding of the farthest unassigned system termination (NS1) from the system centroid (NSCC1). This system termination is then assigned to the region NREG; its incoming and outgoing traffic is added to the partial sum traffic, called TRFS. The resulting TRFS is then tested. If it is greater than TPRL, (lower bound), which is equal to $0.9 \times TPR$, assignment processing for region NREG ends with re-estimating TPR and TPRL which are obtained as follows:

$$TPR1 = TPR1 - TPFS$$

$$TPR = TPR1 / (ANR1 - 1.)$$

$$TPRL = 0.9 * TPR$$

On the other hand, if TPRS is less than or equal to TPRL, additional system terminations can be assigned to this region. The next system termination for addition to this region is selected by finding the nearest unassigned system termination, called NS2, from NS1. NS2 is then assigned to region NREG and its traffic added to TRFS. The value of TRF is again tested against TPRL to determine if other additions are possible.

This process is repeated until partial regional traffic sum TRFS is greater than TPRL. At this point, the region is considered full and addition of system terminations to this region stops. However, if the region being filled is the last one, all remaining system terminations are placed into this last region. Otherwise, the program continues to work on the next region. Before leaving region NREG, it re-estimates TPR and TPRL as shown before.

2.4.3.2 Assigning System Terminations to a Region with Preloading.

If the region NREG is a preloaded region, i.e., it has been preloaded with system terminations, the program continues with a test. The test is needed to determine whether region NREG will accept any additional system terminations. If other insertions to the region are not allowed, the processing on this region stops and continues to the next region.

Otherwise, the program starts adding traffic to all preloaded system terminations to TRFS and finding the farthest unassigned system termination NS1 from the system centroid. It then tests whether TRFS is

greater than TPRL. If it is greater, the program stops here and continues to process the next region.

When TRFS is less than TPRL, the program checks whether there is a preselected RSC for the region NREG. If there is, the program uses the RSC as the NS1. Then it follows the same procedure as described in paragraph 2.4.3.1 to add more system terminations to the region.

It should be noted that STACOM has been implemented in such a way that when it is desired to preload some or all regions, the last one need not be specified. The program will assign the rest of the unassigned system terminations to the last region.

2.4.3.3 Example for Formation of Regions. Figure 2-9 illustrates the results of applying the formation of region logic to a Texas communication system with 265 system terminations. In this example run, neither preloading of system terminations nor preselection of regional switching centers are requested. In other words, the program is asked to perform automatic regional formations and to select the regional switching centers. System termination Austin is chosen as the system centroid.

The total amount of traffic, TPR1 is at a rate of 1585.02/bps, and the number of regions is 2. Therefore, at the beginning, TPR is given as $1585.02/2=792.51$ bps, and $TPRL = 713.26$ bps. In the process of assigning system terminations to region 1, El Paso is found to be the farthest location from Austin, i.e., NS1 = the internal index for system termination El Paso. With NS1 available, the program starts the procedure of searching for NS2, adding its traffic to partial sum TRFS and testing whether TRFS is greater than TPRL. It repeats the same procedure 123 times until TRFS has reached the value of 750.08 bps which is greater than TPRL.

2.4.4 Selection of Regional Switchers

Selection of regional switching centers follows formation of regions as described in Paragraph 2.4.3. For a given region, its regional switching center (RSC) can be either preselected by the user or be chosen by the program. In the latter case, the program selects the system termination within the region such that total intra-region traffic-distance products are minimized.

The functional flow chart of RSC selection is depicted in Figure 2-10. Processing begins with assigning 10^{12} to WCASE (as base for traffic-distance product sum). It then calculates the estimated sum of all traffic-distance products with each system termination in the region as an RSC site. The sum, called SUMT, is obtained as follows:

$$SUMT = \sum_{i=1}^{NMBR} [TRAFFDN(i) + TRAFIT(i)] * DIST(i,K)$$

where

NMBR = number of system terminations in the region under consideration

K = the index of the system termination considered as the trial RSC site

DIST(i,K) = the distance between system termination i and the RSC trial site K

The resulting SUMT is then compared with WCASE. If SUMT is found to be less than WCASE, the value for WCASE is replaced by the value of SUMT and the corresponding index for the RSC trial site is the updated RSC, called NRSC.

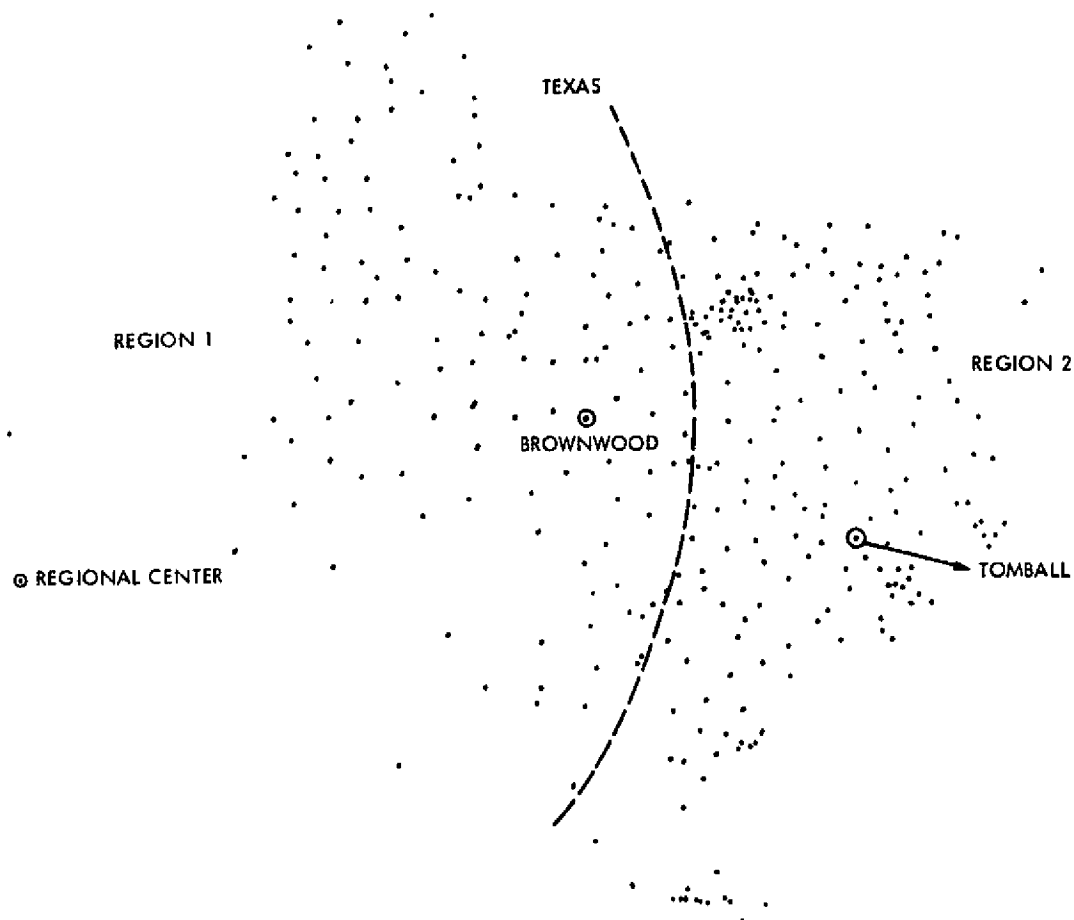


Figure 2-9. Example of Region Network Formation and Regional Switcher Selection

NRSC = INDEX FOR REGIONAL SWITCHING
CENTER

$$SUMT = \sum_{i=1}^{NMBR} (TRAFDN(i) + TRAFIT(i)) * DIST(i, K)$$

 NMBR = NUMBER OF SYSTEM TERMINATIONS IN
THE REGION
 DIST(i, K) = DISTANCE BETWEEN SYSTEM
TERMINATIONS i AND K

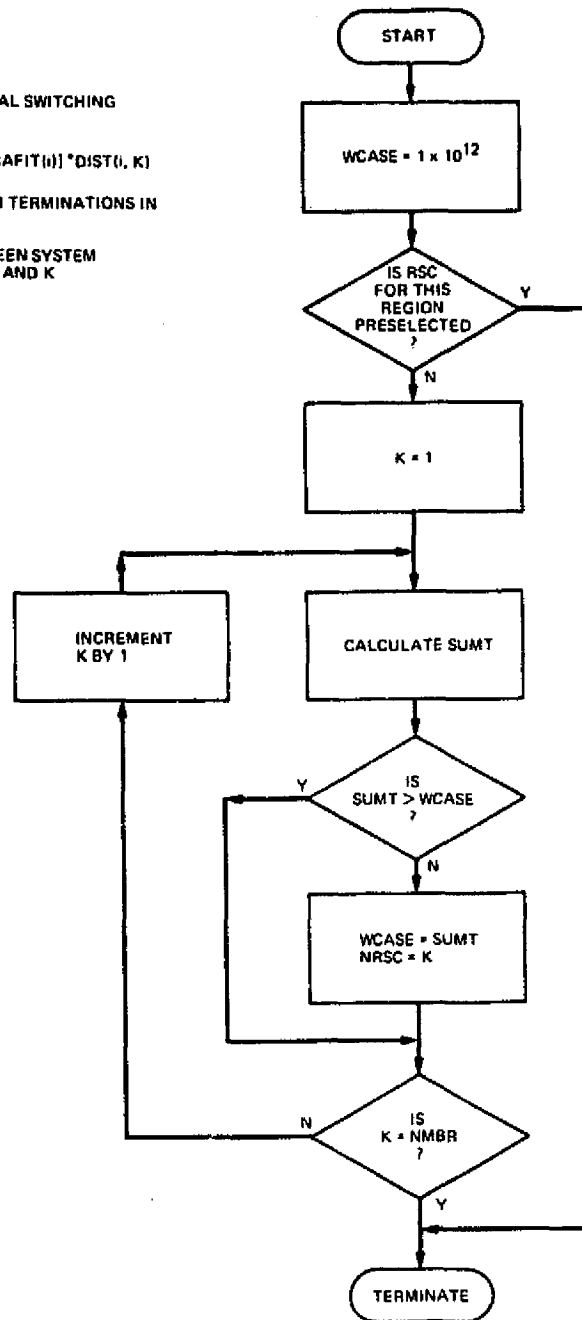


Figure 2-10. Flow Chart for RSC Selection

After the above processing has been repeated NMBR times, the resulting NRSC is the index for the selected RSC and WCASE the region's minimal traffic-distance product sum.

When a regional switching center is preselected by the user, the program skips the process as described here.

Following the selection of a regional switching center for a given region, the program continues to perform regional network formation and network optimization before it repeats the selection of regional switching centers for remaining regions.

The process of regional network formation and optimization is discussed in Paragraphs 2.4.5 and 2.4.6.

2.4.4.1 Example for Selecting a Regional Switching Center. Following the formation of regions in the example given in Paragraph 2.4.3.3, the program has chosen Brownwood of Brown county as the switcher location for Region 1 and Tomball of Harris county as the switcher location for Region 2. Both locations have been found to provide the minimal traffic-distance product sums for respective regions. These two cities are shown in Figure 2-9.

2.4.5 Formation of Regional Star Networks

Formation of a regional network starts with a star network and then continues with an optimization process which, most of the time, results in a cost-saving multidrop network. This subsection describes the process of forming a star network, which is depicted in Figure 2-11. The initial regional network is formed by directly connecting each system termination to the regional switching center. Selection of these intra-region lines is constrained by the rule that each selected line should maintain the line utilization factor, called RHO, at a value less or equal to a preselected number, say, 0.7.

For each system termination in the region, the program finds incoming and outgoing traffic, TRFOUT and TRFIN, and also its distance, DSTN, from the RSC for each system termination in the region. The program calls subroutine LINNUM, which constructs a line configuration LDUMMY and calculates its line utilization, based on the values of TRFIN and TRFOUT provided. The processing continues to calculate both the cost, COST, for the derived line configuration LDUMMY and its response time RSPTIM. Finally, all these data are stored for later printout and comparisons.

The derivation of line configuration LDUMMY by subroutine LINNUM and the associated cost, COST, deserves more explanation. The program assumes that the duplexing mode for all line types under consideration to be half-duplexed. Therefore, subroutine LINNUM will sum up TRFIN and TRFOUT and find an applicable line with the least capacity which assures less than 0.7 of utilization. When the highest capacity line cannot handle the traffic, the routine will try to add one additional line with least capacity until the constraint of 0.7 utilization factor is satisfied. With line configuration LDUMMY obtained, calculation of cost,

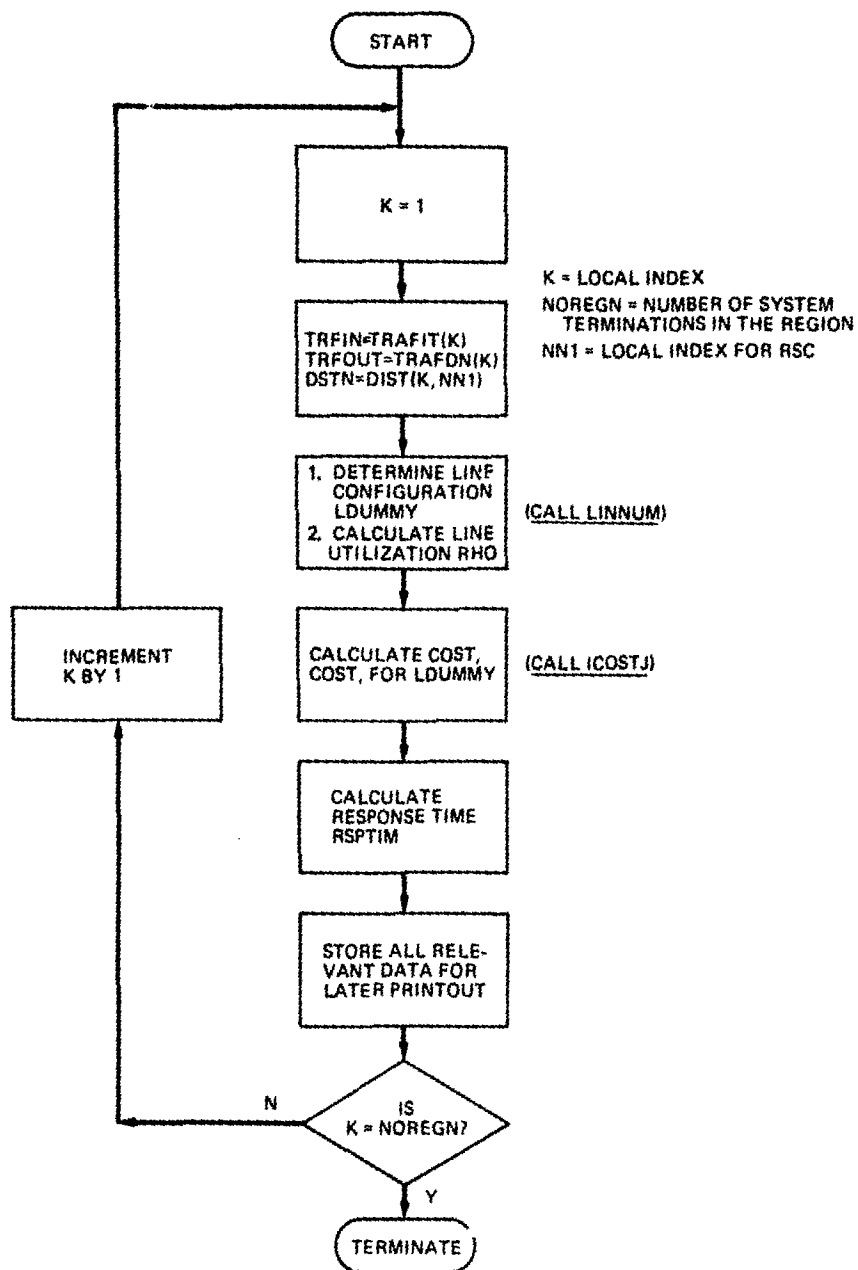


Figure 2-11. Flow Chart for Regional Star Network Formation

COST, for the direct link between system termination K and the RSC is performed by ICOSTJ. The routine ICOSTJ calculates all of the related installation and annual recurring costs for lines and other chargeable items. All of these itemized costs are then summarized as COST. Cost calculations are performed on the basis of the rate structures applicable to system terminations at both ends.

2.4.5.1 Examples of Line Selections. Table 2-1 lists some examples of line configurations results obtained by LINNUM, and illustrates how the LINNUM subroutine selects lines for given traffic. The first column of the table represents total traffic (sum of TRFIN and TRFOUT). In this example, it is assumed that only line types with capacities of 300 bps, 1200 bps and 4800 bps are under consideration. Line utilization factor has been constrained to not greater than 0.7.

2.4.6 Optimization of Regional Networks

After completing the formation of a regional star network, the program proceeds to the optimization process, if requested. The optimization process basically utilizes a technique developed by L. R. Esau and K. C. Williams (Reference 1) and is used to minimize line operating costs. The actual implementation of the technique has been made with several additional constraints for practical reasons.

Before going into detail, here is a brief explanation of the goal and process of network optimization of a regional star network. Figure 2-12 depicts a typical star network in which each system termination has a direct link, called central link, to the central regional center. The goal of optimization is to reduce line costs by eliminating as many central links by connecting the associated system terminations to their nearby system terminations as possible, until it is no longer cost-effective to do so. Figure 2-13 shows a typical multidrop network

Table 2-1. Examples of Line Configurations Obtained by Subroutine LINNUM

Traffic (bps)	Line Type			
	300 bps	1200 bps	2400 bps	4800 bps
200	1	0	0	0
500	0	1	0	0
850	0	0	1	0
1300	0	0	1	0
2000	0	0	0	1
3500	1	0	0	1

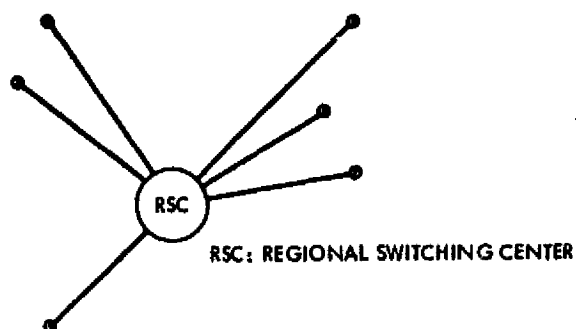


Figure 2-12. Typical Star Network

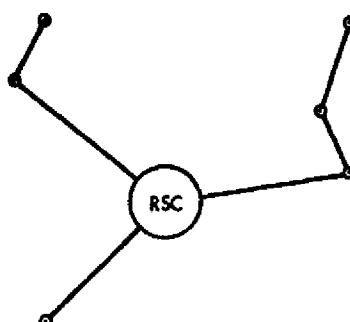


Figure 2-13. Typical Multidrop Network of Optimization

after this goal is met, assuming that the line cost is only a function of distance. While this example as given depicts the main concept of network optimization, it does not illustrate the process of sizing each newly formed multidrop line to reflect the increase of traffic resulting from the addition of new system terminations.

The following section describes the logic implemented in this program.

2.4.6.1 Network Optimization by Esau-Williams Technique. Before explaining the logic for network optimization implemented in the STACOM program, a brief explanation of the Esau-Williams network optimization process is appropriate. With a given star network, the basic process of the Esau-William technique is to repeat two basic steps until it is no longer possible to derive any cost saving.

For the convenience of the following discussion we define a sub-network (subnet) as a tree-type multidrop line consisting of one or more system terminations and having a central link connected to the regional center. Each central link of a given star type network is a simple sub-network by definition.

The first step involves searching for the best central link of a system termination, K, so that its elimination and the subsequent reconnection of the rest of the sub-network to a nearby sub-network L provides the best cost saving. In other words, for each system termination, i, with a central link to the regional center, this routine estimates the best saving, S_i , resulting from eliminating the given central link and reconnecting the rest of the subnetwork to a nearby subnetwork beginning with L_i . If we express it as a formula, then

$$K = i \text{ such that } S_i = \max_{j \in C} \{S_j\}$$

$L_i = j$ for which the integration of K and L sub-networks provides S_K which is the best saving

where

C = the set of system terminations with central links to regional center

j = the first system termination of sub-network L

The other step involves network updates after it has been determined that the central link from system termination K is to be eliminated; this step will integrate remaining subnet K with subnet L utilizing an alternate route.

It should be noted that although this network optimization process will generate the best network most of the time, it does not always provide the best one. In other words, this technique generates the local optimal solution rather than the global solution. This is because the first selection of a central link for elimination dictates the final network to be created by repeating the process as described above. However, as shown in Reference 4, the process does provide a solution which is always close to, if not, the best.

2.4.6.2 Network Optimization Logic in STACOM Program. The optimization logic as implemented in the STACOM program basically utilizes the Esau-Williams technique. However, constraints have been incorporated into it in order to satisfy project requirements and to eliminate unnecessary searching. Figure 2-14 shows the functional flow chart for the overall logic.

The optimization process starts with the test to see whether there is only one sub-network left. If this is true, it stops. Otherwise, the program, utilizing four variables K, L, M and KI, starts evaluating possible cost saving by eliminating central link K and

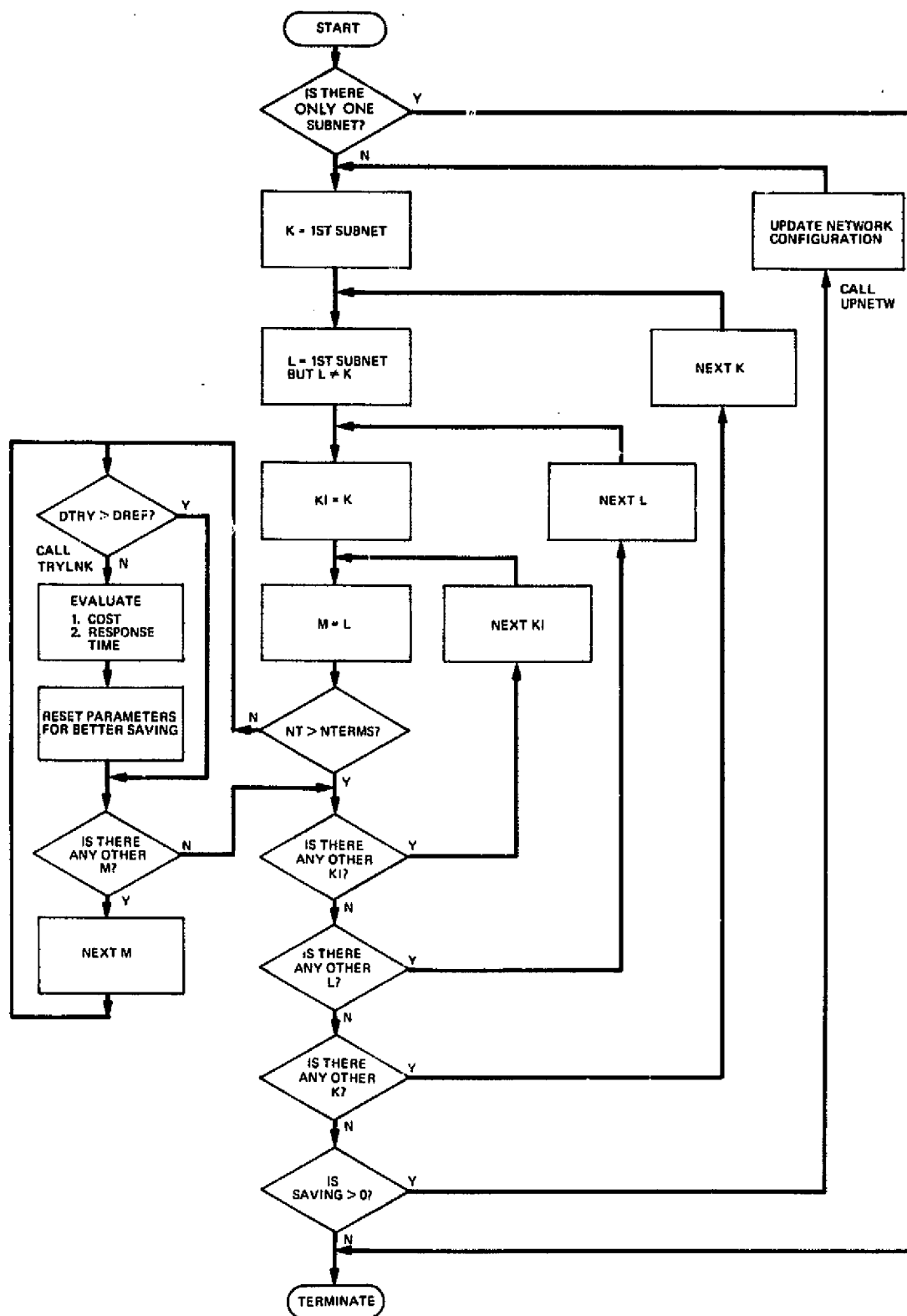


Figure 2-14. Flow Chart for Subroutine ESSWIL

reconnecting the rest of sub-network K to sub-network L through system terminations M of L and KI of K as shown in Figure 2-15.

Selections of values for variables K, L, M, and KI are in the following way. For each processing cycle, searching and updating, K is assigned the index values from the first sub-network to the last one of the existing network. For each K, L is assigned index values from the first sub-network to the last one except $K \neq L$. With values for K and L chosen, M is assigned the index values of all the system terminations on sub-network L and KI the index values of all the system terminations on the sub-network K.

For each given set of K and L, the program tests whether the sum, NT, of numbers of system terminations for both sub-networks exceeds the value of NTERMS which constrains the number of system terminations on a multidrop line. If this is true, it skips the process of calling on subroutine TRYLNK, because it is not possible to integrate both sub-networks without violating the said constraint. Otherwise, it continues to the distance test.

K = THE SUBNETWORK BEGINNING WITH SYSTEM TERMINATION K
 L = THE SUBNETWORK BEGINNING WITH SYSTEM TERMINATION L
 M = THE SYSTEM TERMINATION ON SUBNET L TO WHICH KI IS TO BE CONNECTED
 KI = THE SYSTEM TERMINATION ON SUBNET K FROM WHICH SUBNET K IS CONNECTED TO M OF SUBNET L
 DREF = THE DISTANCE BETWEEN SYSTEM TERMINATIONS K AND THE RSC
 DTRY = (THE DISTANCE BETWEEN SYSTEM TERMINATIONS KI AND M)/2

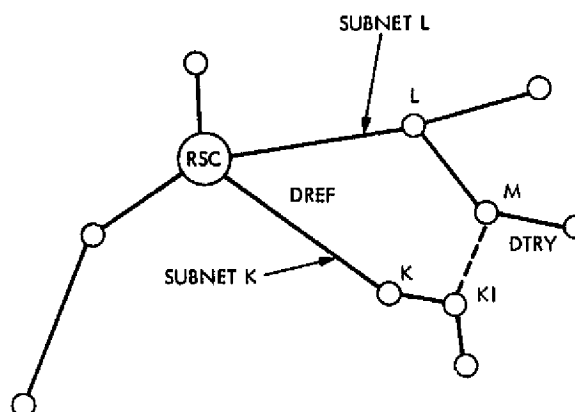


Figure 2-15. Relationship among K, L, KI, and M Parameters

The program first calculates the distance DREF between system termination K and the region switching center for each K, and then the DTRY which is half of the distance between system terminations KI and M for each combination.

If DTRY is greater than DREF, the program skips the process of calling on subroutine TRYLNK. Otherwise, it calls on subroutine TRYLNK. The purpose of subroutine TRYLNK is to estimate the possible cost saving resulting from eliminating central link K, and integrating sub-networks K and L by connecting system terminations KI of K and M of L. If the saving is better than the maximum saving obtained so far, it is used as the up-to-date best cost saving under the set of values for K, L, KI, and M. A detailed description of functions performed by subroutine TRYLNK is given in Paragraph 2.4.6.3. After all possible combinations for K, L, KI, and M have been tested and it has been found that the up-to-date best cost saving is positive, the program performs the second function of network optimization, i.e., updating the network. It then repeats the whole process on the newly updated network which happens to have one less central link.

If the up-to-date maximum cost saving is non-positive, the optimization process stops here.

2.4.6.3 Function Performed by Subroutine TRYLNK for a Given Set of Values K, KI, L, and M. The processing, as shown in Figure 2-16, starts with estimating the total amount of traffic that a single multidrop line (sub-network) of integrating subnetworks K and L needs to handle. It then estimates the required line configuration, LDUMMY, by calling subroutine LINNUM which has been described in Paragraph 2.4.5.1. Based on LDUMMY, the program estimates the average response time and tests it against the user-provided response time limit by calling subroutine RSPNSE. If the estimated response time is not satisfied, the program updates the line configuration LDUMMY to the next higher line type and repeats the process of estimating its average response time and testing it against the given constraint. This process ends when either there is a satisfied line configuration or it is not possible to upgrade any further.

When a satisfied line configuration is obtained, the program continues to estimate its cost saving, based on the assumed integrated sub-network. If the resulting cost saving is better than the up-to-date best cost saving, it replaces all of the maximum saving parameters, which are used to keep tracking the up-to-date best network changes; it then returns to its calling routine. If there is no line configuration satisfying the response time constraint, the process stops and the program returns to its calling routine.

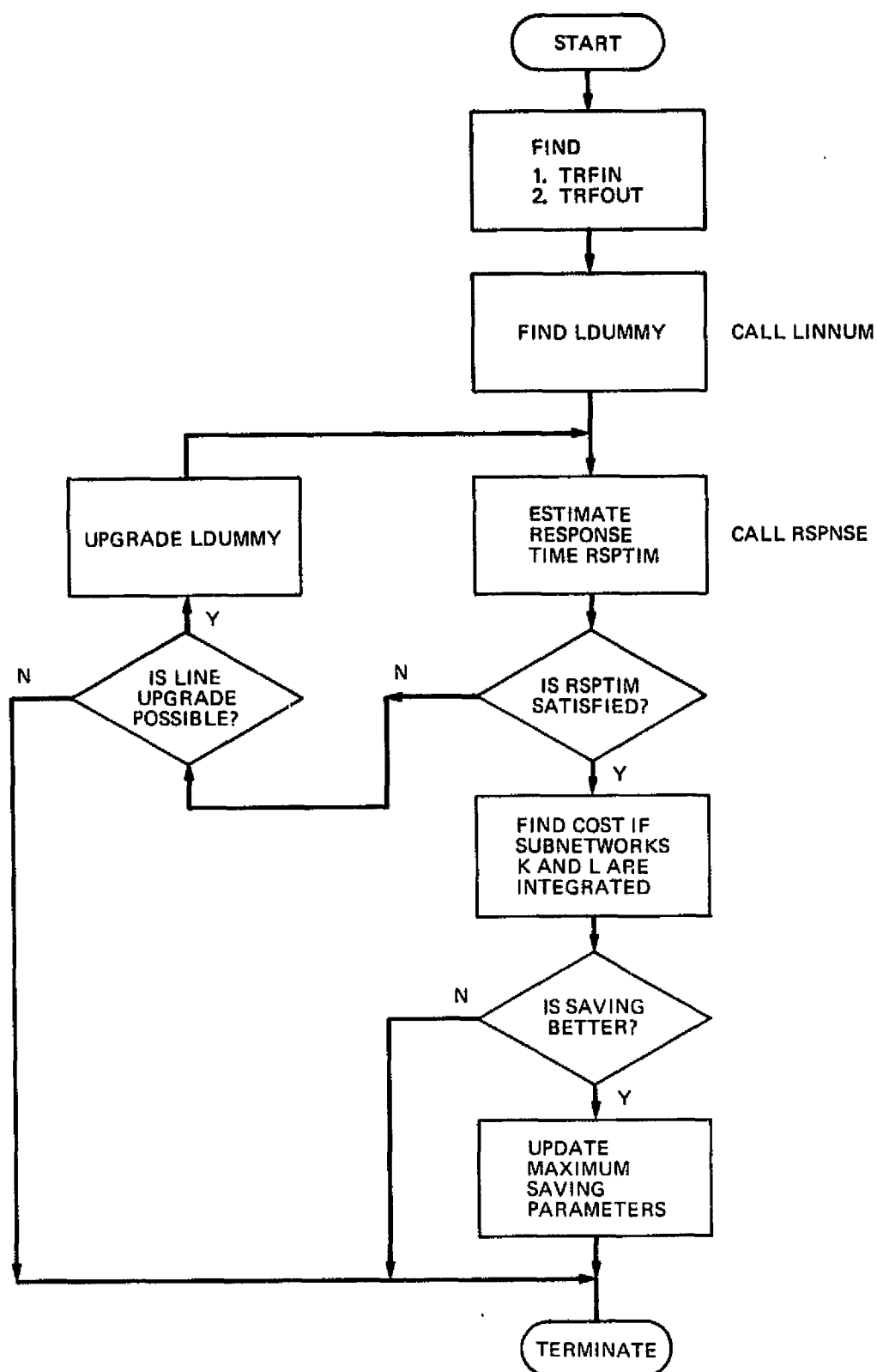


Figure 2-16. Flow Chart for Subroutine TRYLNK

2.4.6.4 Functions Performed by Subroutine RSPNSE. Figure 2-17 shows the flow chart of the subroutine RSPNSE. This subroutine calculates six items of delays: polling, message transmission time from a terminal to the central switches, input buffer queue time, service time, output buffer queue time, and returned message transmission time from the central switcher to the same terminal.

After summing up these delays as RSPTIM, this subroutine compares its value with the upper bound response time as set up by the user. It assigns 1 to IOK as an indication of satisfying response time requirement and returns.

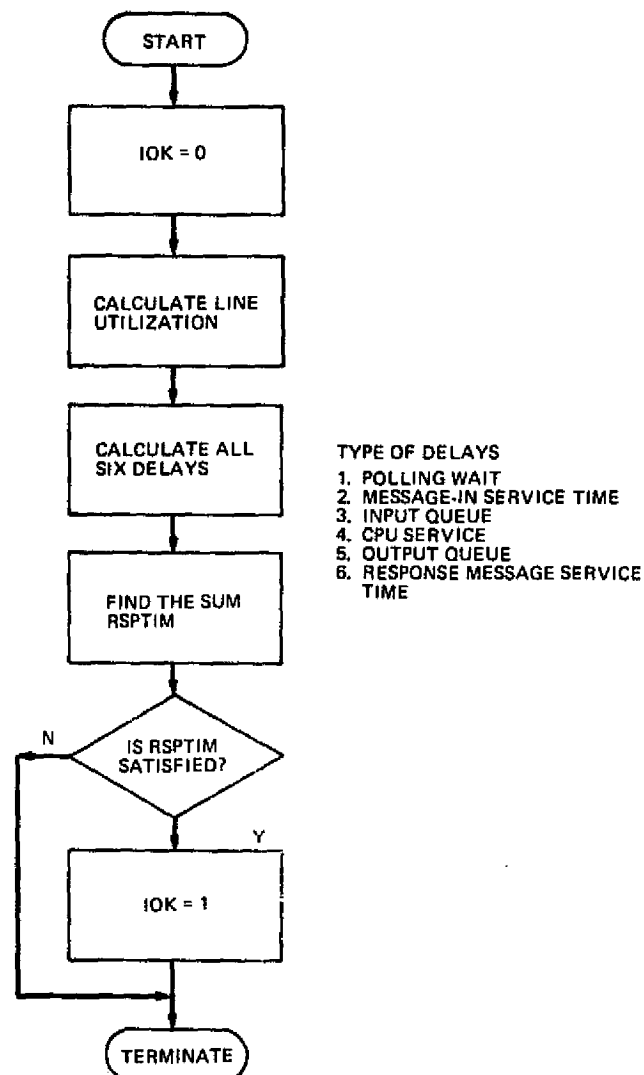


Figure 2-17. Flow Chart for Subroutine RSPNSE

2.4.6.5 Network Updates by Subroutine UPNETW. If there is a positive cost saving after trying all possible combinations for parameters K, KI, L, and M, subroutine UPNETW is called upon to perform the other function for each cycle of the network optimization process as described in Paragraph 2.4.6.1.

In the STACOM program, subroutine UPNETW performs the following main functions: (1) updating of network descriptions, (2) revision of relevant accounting data (such as the number of terminals on the new L sub-network, its average response time, and total traffic).

2.4.7 Formation of an Interregional Network

The interregional network is formed by erecting communication lines between the regional switching centers (RSCs). The initial network has a direct line between any two RSCs.

As shown in Figure 2-18, for each combination of two RSCs I and J, the maximum traffic in either direction is considered as the design traffic between these two RSCs. This is different from intraregional line selection because it is assumed that full duplex lines are to be used. The traffic matrix TRM contains traffic data between RSCs. With this information, line configuration LINEQU between RSCs I and J is obtained by calling subroutine LINNUM.

Cost of line configuration LINEQU is then estimated and added to the total cost.

2.4.8 Optimization of an Interregional Network

After the initial interregional network is completed, the program starts a line elimination process in order to obtain a cost-effective network.

Figure 2-19 shows the basic topological consideration involved in line elimination. In considering whether line I-J can be eliminated, the algorithm tries to divert I-J traffic to other lines with excess capacity, for example, over route 1-4-3. If there is no alternate route with enough excessive capacity to handle I-J traffic, the program begins adding capacity to alternate routes in order to accommodate the required traffic. It then estimates the cost saving under the proposed modifications.

The algorithm iterates the above described process for all combinations and records the best cost saving and the best line elimination. It then updates the network.

This cycle of searching for the best cost saving and updating the network repeats continuously until cost savings can no longer be realized.

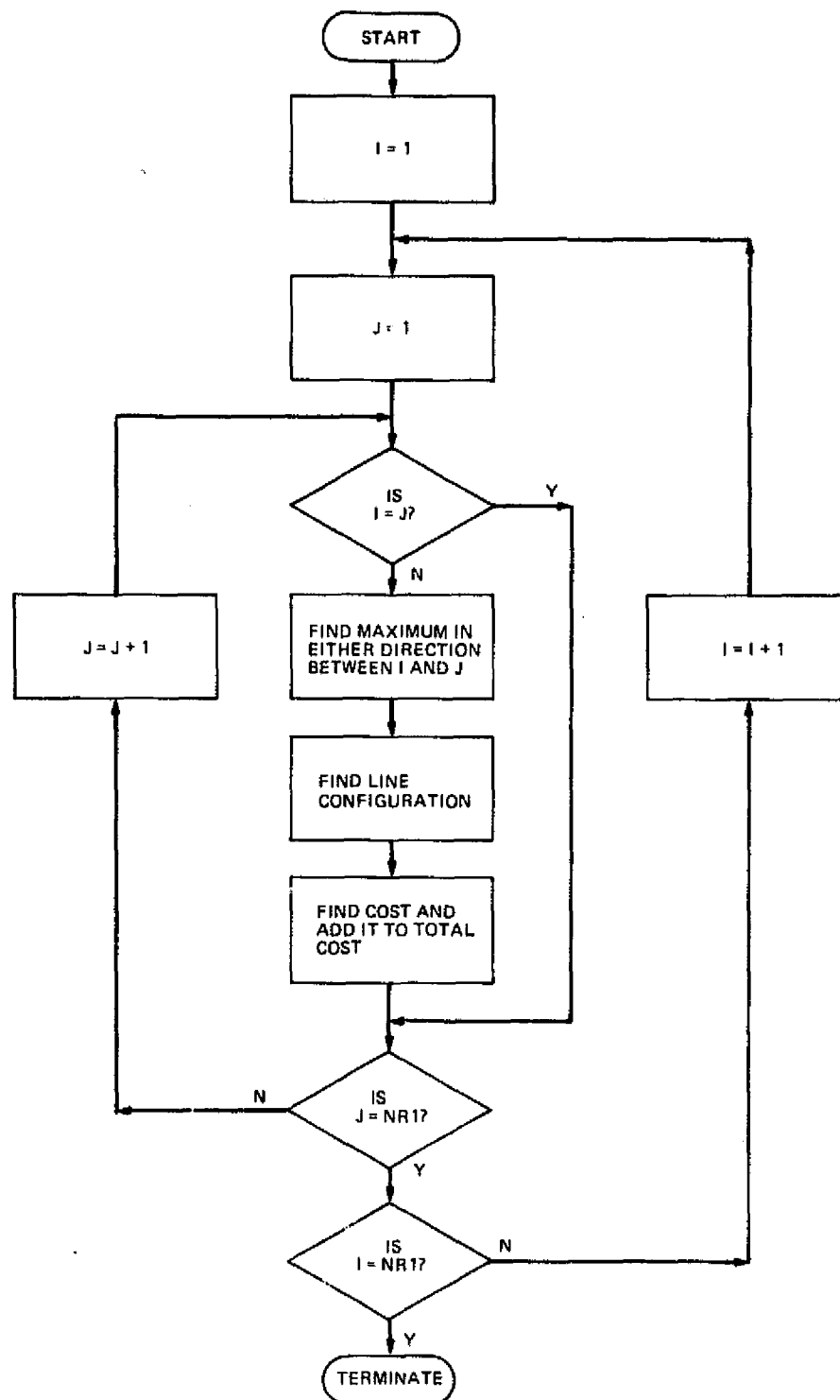


Figure 2-18. Flow Chart for Intraregional Line Selection

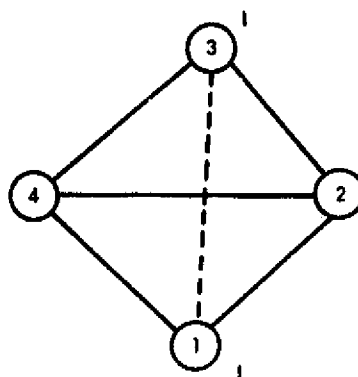


Figure 2-19. Basic Topology of Line Elimination

2.4.8.1 Interregion Network Optimization Logic Implemented. Figure 2-20 depicts the functional flow chart for the interregional network optimization as implemented in the STACOM program.

A parameter, I, is used to select one of the RSC nodes to be considered for line elimination. A test is then made on RSC I to insure that at least three links to other RSCs exist. If I has at least three links, another parameter, J, is used to select any other RSC node for trying to eliminate its link to I. J is tested to insure that it has three links to other RSCs and J is different from I. Another test is made to insure that I and J are connected to each other. If any of these conditions are not met, RSC node J + 1 is selected and these three tests are repeated.

If these conditions are met, a test is carried out to see if sufficient network connectivity will still be maintained if connection I-J is removed. Due to the consideration of availability, the program is designed in such a way that each RSC node will have at least two communication links to other RSCs and each RSC node will be connected to every other RSC node through no more than one intermediate node.

If the network connectivity requirement can be maintained with the removal of link I-J, the program searches for alternate routes with excess capacity in an effort to re-route the I-J traffic load without increasing network capacities. If all I-J traffic can be successfully diverted in this manner, the I-J link is eliminated and the network traffic matrix and costs are re-calculated; the process then begins anew.

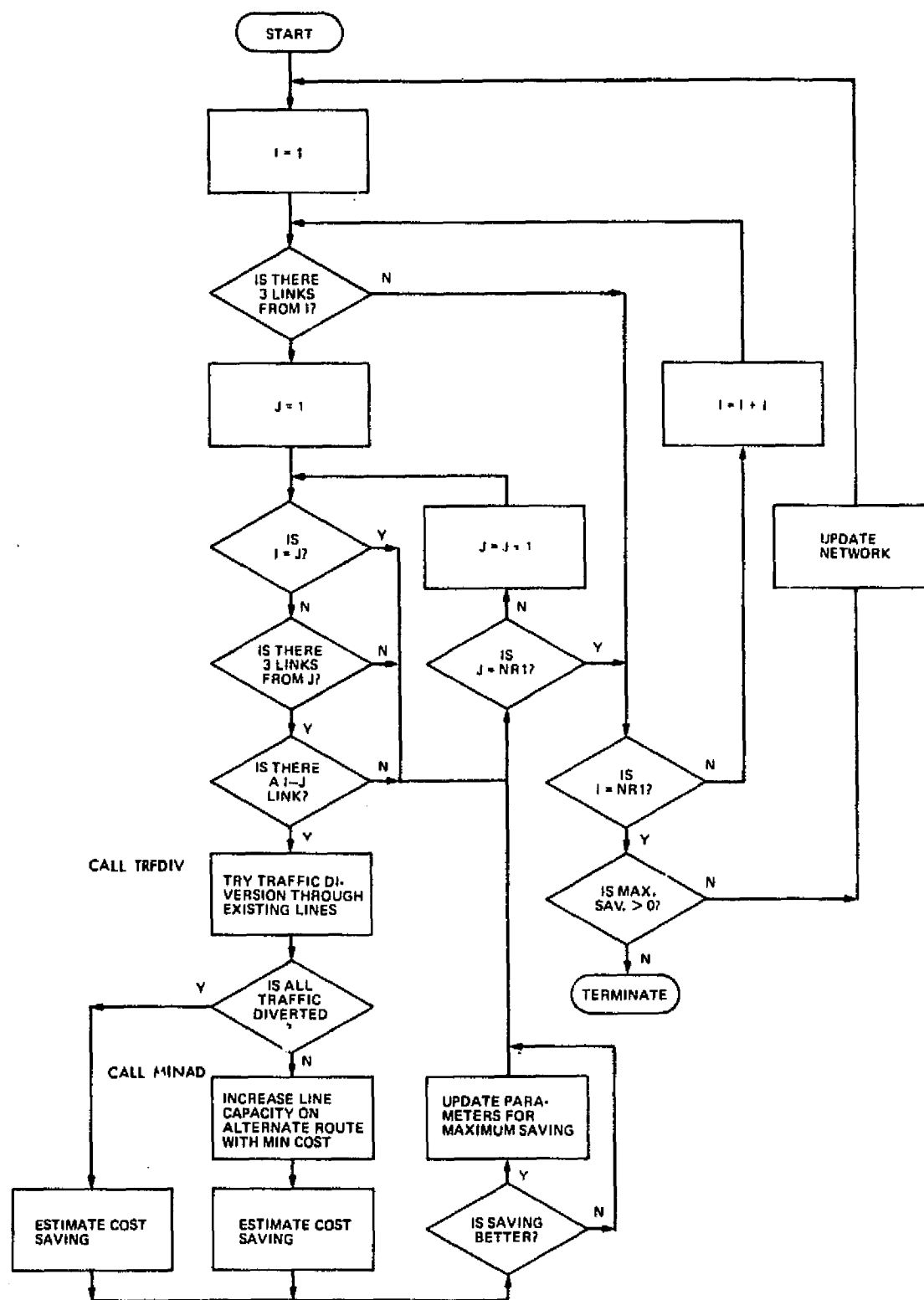


Figure 2-20. Flow Chart for Interregion Network Optimization

If all I-J traffic cannot be diverted through existing network routes with excess capacities, the capacity of the first available alternate route is increased to handle the remaining traffic. The cost saving is determined as equal to the original cost of the line removed minus the cost for the capacity increase. If the cost saving is an improvement over previous trials, line and traffic data are saved to reflect the up-to-date best modification of the network.

At the conclusion of each cycle, if the cost saving is positive, the line and traffic data associated with the best saving are used to eliminate the line, update the network, and recast the network.

The process is continually iterated for each updated network configuration until cost savings are no longer positive.

2.5 OUTPUT

The STACOM program generates regular printer output and a CalComp plotter output. In addition, when the program is run as a demand job, run-status output will show up on the interactive terminal. This part of the printout provides information on the progress of the run.

Details of data contained in the regular printer output are given in Paragraph 2.5.1; Paragraph 2.5.2 describes the CalComp plot.

2.5.1 Printer

The printer output contains all the data resulting from the running of the STACOM program. The amount of printout data depends upon the number of system terminations operated and also upon the number of functions executed in each specific run.

Following is a list, in temporal order, of the data items which a run may produce.

2.5.1.1 Line Type and Transmission Line Characteristics. The first set of data are the line type and transmission line characteristics as used in the run. For each line type, the polling protocol data and modem turn-around time data, etc., are provided.

2.5.1.2 Message Characteristics. Message characteristics are the next set of data output from the program. They include average input message length, average output message length and overall average message length.

2.5.1.3 Preloading of System Terminations and Preselection of Regional Switcher Locations. If there are any preloadings of system terminations and/or pre-selections of switcher locations, this information will be provided in the printout. Otherwise, no data will be shown in this regard.

2.5.1.4 Traffic and Distance Tables. These are tables which show both traffic from/to all system terminations and distances between system terminations.

The first table gives the traffic data from each system termination to/from each data base; the next one gives the traffic data destined to and originating from each system termination. The last table shows the distance data between any two system terminations.

2.5.1.5 System Centroid and the Utilization Factor of the Central Switcher. The system centroid as designated by the user is printed next as a reminder. After this, the CPU utilization factor of the central switcher as calculated by the program is printed to indicate the load.

2.5.1.6 System Terminations in a Region and its Regional Switching Center. For each region, the program prints out the identification and name of each system termination in the region. These system terminations may have been pre-loaded or assigned to the region by the program. The program also prints out the location of the RSC for the region, which is either pre-assigned by the user or selected by the program.

2.5.1.7 Star Network and its Costs. After showing what system terminations are in the region, the program prints out the regional star networks and costs associated with each central link. It also provides summarized costs. Detailed descriptions for each central link are given below.

2.5.1.7.1 Line Configuration and Effective Utilization. The line configuration for each central link is printed as a column vector, which has the same number of line types used in the run. The effective line utilization is also printed to show the traffic load from the system termination.

2.5.1.7.2 Distance. The distance from the system termination to the regional switching center is printed.

2.5.1.7.3 Line Traffic and Effective Response Time. The amount of traffic from/to the system termination is printed before the effective line response time as calculated by the program is printed. The calculation is based on the line configuration and traffic as shown and should be better than the response time requirement.

2.5.1.7.4 Installation and Annual Recurring Costs. The installation and annual recurring costs for providing the central link are given in terms of chargeable items such as service terminal, modem, line and drop. Partial sums for the line are also printed. Finally, total installation and annual recurring costs for each chargeable item and for the overall star network are printed.

2.5.1.8 Final Optimized Network and its Costs. After performing optimizations on the star network, the program prints out descriptions for each multidrop line in the final optimized network. The following list shows the data items which may be printed.

2.5.1.8.1 Multidrop Line Configuration. Each multidrop line has an index, the beginning terminal and number of terminals on the line. The exact line configuration is printed as a column vector, with only one non-zero element. The content of that non-zero element must be one, due to the fact that multidropped terminals can only perform on one line.

2.5.1.8.2 Line Utilization, Mileage, Traffic, and Response Time. The line utilization, total mileage and incoming/outgoing traffic on each multidrop line are printed. The program next prints the average response time, which should be better than that required by design, to be expected by each user terminal on the line.

2.5.1.8.3 Installation and Annual Recurring Costs. The amount of installation and recurring costs are then listed in terms of chargeable items as explained in Section 2.5.1.7.4.

Finally, total installation and annual recurring costs for each chargeable item and for the overall network are printed.

2.5.1.9 Network Drawing. A network diagram in terms of tree-type relationship is last printed. It uses the system termination identification as nodal notation.

2.5.1.10 Initial Interregional Network. If formation and optimization of the interregion network is required, the program will perform these functions and print its initial and optimized network. For each pair of RSCs, the program prints out line names, configuration, utilization, and installation and recurring costs. Total network cost is also provided.

2.5.1.11 Optimized Interregional Network. The program prints out similar data for the final optimized interregional network after completing the network optimization.

2.5.2 CalComp Plot

A CalComp plot subroutine has been incorporated into the STACOM program for the purpose of providing a visual plot of each optimized regional network obtained by the optimization process. The subroutine converts each final optimized regional network into a two dimensional plot, utilizing the CalComp plotter. It should be noted that the CalComp plot is an optional product. If desired the user can command the STACOM program not to generate the plot.

2.6 SYSTEM CONFIGURATION

In this section, we will describe the basic computer system required to run the STACOM program.

2.6.1 Hardware

The following list describes the hardware units that should be part of the computer system on which the STACOM program is run.

2.6.1.1 Central Processing Unit. Due to the fact that the STACOM program is coded with the FORTRAN V language and compiled and mapped under the EXEC-8 operating system of the UNIVAC 1108 systems, a UNIVAC 1108 CPU or one equivalent to it is a prerequisite of the use of the STACOM program. When this type of CPU is not available, some conversion efforts on the STACOM program may be required.

2.6.1.2 Main Core Storage. Although the core size required by the STACOM program varies by parameter values assigned, it is generally true that 65K words would be a minimal requirement.

2.6.1.3 CalComp Pen Plotter. A CalComp pen plotter is required for the use of the STACOM program. If other types of CalComp plotters, e.g., CalComp Model 1675 are to be used, the plotting subroutine of the STACOM program needs to be revised.

2.6.1.4 Line Printer. A regular printer to receive FORTRAN output files is needed. It will print out all run results collected by file 100.

2.6.1.5 Demand Terminal. A demand terminal provides the user with an alternate way of running the STACOM program, although the program can be run as a batch job. With the demand terminal, a user can interactively perform the program execution.

SECTION 3

PROGRAM OPERATIONS

3.1 INTRODUCTION

This section is intended for use as a reference manual for the user, both to prepare input data and to operate the STACOM program. With this in mind, this section is devoted to an explanation of how input data are prepared, how the program is executed, and what the input/output of the program is to be.

3.2 ENVIRONMENT

3.2.1 Hardware

The following list describes the hardware units that should be part of the computer system on which the STACOM program is run.

3.2.1.1 Central Processing Unit (CPU). Because the STACOM program is coded with the FORTRAN language and compiled and mapped under the EXEC-8 operating system of the UNIVAC 1108 systems (see Paragraph 1.1), a UNIVAC 1108 CPU or one equivalent to it is a prerequisite for using the STACOM program. When this type of CPU is not available, some conversion effort on the STACOM program may be required.

3.2.1.2 Main Core Storage. Although the core size required by the STACOM program varies with the parameter values assigned, it is generally true that 65k words would be a minimal requirement.

3.2.1.3 CalComp Pen Plotter. A CalComp pen plotter is required for the use of the STACOM program. If other types of CalComp plotters, e.g., CalComp Model 1675, are to be used, the plotting subroutine of the STACOM program has to be revised.

3.2.1.4 Line Printer. A regular line printer to receive FORTRAN output files is needed. It is to print out all run results collected by file 100.

3.2.1.5 Demand Terminal. A demand terminal provides the user with an alternate way of running the STACOM program, although the program can be run as a batch job. With the demand terminal, a user can interactively perform the program execution.

3.2.2 Software

3.2.2.1 Programming Language. The STACOM Program is implemented with the FORTRAN V language of the UNIVAC system, compiled by the EXEC-8 FORTRAN Processor FOR, and mapped by the mapping processor MAP. Because of the inclusion of a plotting subroutine, the system library file LIB*PLOT\$ is required during mapping.

An understanding of the FORTRAN V features is available in Reference 2.

3.2.2.2 Operating System. The EXEC-8 operating system of the UNIVAC 1108 computer system is used in the development of the STACOM program. As this operating system has been used for executing regular FORTRAN V programs this same operating system must be used for executing the current edition of the STACOM program.

The STACOM program has been designed so that all of the desired printer output will be dumped to file 100. Therefore, before executing the STACOM program, an alternate file 100 must be assigned. Otherwise, regular WRITE unit 6 will be the destination device; this will make it awkward when runs are performed via a demand terminal since most of the output from the program uses 132 characters per line.

Furthermore, an execution of the program will generate a punch-card image file. It is, therefore, recommended that a file be assigned to store the punch-card file, and that this later be directed to a CalComp plotter. An alternative is to have a command statement which requests the operating system to @SYM the output punch-card file to a CalComp pen plotter.

3.2.3 Functional Limitations

While the STACOM program has been designed and implemented with the intent that it be as widely applicable as possible, it does have certain limitations. Following is a list of functional limitations that exist in the program.

3.2.3.1 Program Size. Under the EXEC-8 operating system, the size for regular programs is limited to 65k words per program. Because of this, assignments of parameter values during the compilation stage are conditioned to this limit of the overall program size when mapped. Although it will be more convenient for later uses of the STACOM program if all of the parameters are assigned with maximum values within the limit of 65k words, this will increase the run cost. This is because of the core-time product charge.

3.2.3.2 Parameter Variables. The PARAMETER statement of the FORTRAN language is one of those commands which make the language a powerful tool in problem solving.

To accomplish the goal of making the STACOM program a widely usable tool for network design, it has been implemented with several parameter variables. For each compilation of the program, a set of values is assigned to the parameter variables. Therefore, any subsequent use of the STACOM program will be limited to cases where the actual values assigned to the variables are within the parameter values defined during compilation. Any run whose input data violates this rule will need modification of the parameter values of the program, recompilation, and remapping. For example, NPI is a parameter variable which is used to make the number of system terminations allowed in a system a variable. A choice of NPI as 105, for example, dictates that the STACOM program can only be used in systems where 105 or less system terminations are under consideration. Any run which has a number of system terminations greater than 105 will result in either an abnormal run termination or a normal run termination with unwanted output.

3.2.3.3 Response Time. The response time algorithm implemented in the program is based on the model (Reference 5). In applying this program to a given system, some consideration of the applicability of the response time algorithm is required. If the central switcher does not behave similar to this model the response time subroutine RSPNSE has to be revised and recompiled and the STACOM program has to be re-mapped.

3.2.3.4 CalComp Plot. The graphic output portion of the STACOM program has been implemented with the plotting routines designed for the CalComp pen plotter. If other types of CalComp plotters, e.g., CalComp Model 1675, are to be used, the plotting subroutine of this program needs to be revised and recompiled and the STACOM program has to be re-mapped.

3.3 RUN DESCRIPTION

3.3.1 Initialization and Setup

When the STACOM program is executed from an 80-character/line demand terminal, an alternate file, 100, to be used as a printer output file, must be defined. Otherwise, all printout data will be directed to the terminal which will produce interleaving output. The statement @ASG,UP 100 defines the alternate file.

In addition to the redirection of output file destination, the user has to direct the punch-card file to a proper unit for a CalComp plotter. As an example, the statement @SYM,P PUNCH\$,G9PLTF will direct the punch-card images to a CalComp plotter designated with G9PLTF.

The preparation of input data can be best described by referring to Table 3-1 which shows all of the data items with their required formats. The table is self-explanatory, but some of the data items deserve additional description.

Because the exact number of data bases varies from State to State, the format for item 5 allows a maximum of 5 data bases wherein the last three pairs of entries must be given on a separate card.

The notation [X] for item 8 indicates that the exact value is equal to the next integer which is greater than or equal to X. The format for line recurring costs has been designed with the assumption that both linear and nonlinear functions will be used in tariffs for line services. Because of this, the STACOM program provides options for either scheme. When a cost function is nonlinear, it is assumed to be stepwise and only eight steps are allowed. If eight are not enough, the program has to be updated.

The amount of input data for item 15 varies from one run to another. The program has default values of zeros for all entries in IACTN (NR1,2). A zero for the first element indicates the acceptance of additional system terminations into a region when it is a preloaded region; a zero for the second element indicates that the optimization process for the region is not needed.

When a user decides either to exclude the addition of other system terminations into a preloaded region, or to request an optimization process performed upon a specific region he must so inform the STACOM program by adding data cards with two integer numbers. The first number gives the region index; the second number indicates the action: 1 indicates insertion exclusion, and 2 indicates optimization. When all requests for actions have been made, a card with two zeroes is required to indicate that fact.

Finally, item 20 provides the tool for a user to preload system terminations to certain regions, and/or preselect the regional switching center. Three numbers are needed for each action. The first number, called NCODE, directs the specified action: 1 assigns a system termination to a specific region; 2 assigns a system termination as the RSC for a specific region. The second number, called NSTATE, gives the identification number for a system termination to be assigned to a region or to be selected as an RSC. The third number, called NREGQ, designates the region to be acted upon. When the first number has a value of three, the assignment selection activity terminates.

3.3.2 Run Options

As indicated in Table 3-1, there are several independent variables provided only at the time of execution. This provides additional capabilities to the STACOM program.

Table 3-1. Formats for Input Data

Item No.	Item Description	Names of Internal Variables/Arrays	Number of Cards Needed	Formats
1.	No. of regions under consideration	NR1	1	(I3)
2.	No. of system terminations, no. of data bases, and no. of distinctive cities under consideration.	N1, N7, NCITY	1	(3I5)
3.	IDs for data bases	NBASE(N7)	1	(3(1X,A4))
4.	V-H Coordinates for cities	IVERT(NCITY), IHORZN(NCITY)	NCITY	(33X,I5,2X,I5)
5.	ID, name, city index, additional no. of terminals and traffic to/from each data base for each system termination.	INDXPT(N1),NAMEST(H,N1),IADD(N1) MAPADR(N1),TRAFFD(N1,2,N7)	a. N1 if $N7 \leq 2$ b. 2N1 if $N7 > 2$	(A4,1X,3A6,A4, I2,I4,4F10.2/ 6F10.2
6.	No. of rate structures	N2	1	(I3)
7.	Rate application matrix	IRATEJ(N2,N2)	N2	(10I2)
8.	Traffic density index and applicable rate structure for each city	IRAND(NCITY,2)	[NCITY/40]	(80I1)
9.	No. of applicable line types	N3	1	(I3)

Table 3-1. Formats for Input Data
(Continuation 1)

Item No.	Item Description	Names of Internal Variables/Arrays	Number of Cards Needed	Formats
10.	Name, capacity, utilization limit, usage and duplexing mode for each line	LINAME(N3), LINCAP(N3), LINMIX(N3), IDUPLX(N3)	N3	(A6,1X,I6,1X, F3.2,2(1X,I1))
11.	No. of chargeable items	N4	1	(I3)
12.	Names of chargeable items	NAMEHW(N4)	1	(10(A6,1X))
13.	Installation and recurring costs for chargeable items WRT rate structure, traffic density and duplexing mode for each line type	AINSTC(N2,N3,N4,3,2,2), RECRC (N2,N3,N4,3,2,2)	2xN2xN3xN4x3x2	(2F9.2)
14.	Linear installation and recurring costs for lines WRT rate structure type, density, and duplex mode	IFLAG(N2,N3),ANSTLN (N2,N3,3,2,2), RECRLN (N2,N3,3,2,16)	a. N2x(2+N3x3x2) b. 2xN2(2+N3x 3x2) if non linear	a. (4F9.2/I1/10F8.3) b. (4F9.2/I1/10F8.3/ 10F8.3)
15.	Action indices for regions	NREG,NCODE for IACTN (NR1,2)	Variable	(2I2)

Table 3-1. Formats for Input Data
(Continuation 2)

Item No.	Item Description	Names of Internal Variables/Arrays	Number of Cards Needed	Formats
16.	No. of polling characters no. of NAK characters, no. of polling overhead characters, no. of NAK overhead characters, message overhead characters, Modem turnaround time, and other delay for each line type	NPL(N3), NAK(N3), NPLOH (N3) NAKOH(N3), MOH (N3) TAMDM(N3), TAPD (N3)	N3	(5I4,2F7.5)
17.	No. of message types	NTYP	1	(I4)
18.	Message name, input message length, output message length, input percentage and output percentage with priority 1 and 2	MSGNAM (NTYP), MSLIN (NTYP) MSGOVT(NTYP), RATIOI(NTYP,2) RATIO(NTYP,2)	NTYP	(A6,2(2I4,2F6.3))
19.	Average CPU service time per transaction	CPUAVG	1	(F7.4)
20.	Preloading system terminations and/or preselecting regional centers	NCODE, NSTATE, NREGQ	Variable	(I1,1X,A4,A5)
21.	System Center	NSCC1	1	(A4)

Table 3-1. Formats for Input Data
(Continuation 3)

Item No.	Item Description	Names of Internal Variables/Arrays	Number of Cards Needed	Formats
22.	Total no. of messages per second and no. of requests made at the central switcher	XSAC, NREQSW	1	(F8.5,I3)
23.	Limit on no. of terminals on a multi-dropped line, response time requirement and no. of CPU processors for computer	NTERMS, TIMREQ, MPROC	1	(I3,F5.2,I2)
24.	Plot request	MPLOT	1	(I3)

Following is a list of run options for the STACOM program.

- (1) The user can preload system terminations to regions and/or preselect regional switching centers.
- (2) The user can select certain regions for which the optimization process will be performed.
- (3) Type of lines and chargeable items can be selectively chosen.
- (4) The user can put a limit on the number of terminals on a multidrop line as described and can limit the average terminal response time.
- (5) The number of central processor units in the central computer system can be 1, 2, or 4.
- (6) The CalComp plot can be skipped.

3.3.3 Control Instruction and Sequences

3.3.3.1 Starting a Run.

3.3.3.1.1 Batch Mode. Following is a list of control statements required when running the STACOM program as a batch run:

```
@RUN run-ID, account-no., project-ID, SUP-time, pages/cards
@ASG,UP 100
@SYM,P PUNCH$, ,plotter-ID
@XQT file.STACOM
      (DATA)
@BRKPT 100
@FREE 100
@SYM 100,,printer-ID
@FIN
```

The RUN card gives the following information: designated run-ID, user's account number, project-ID, expected SUP-time usage and limited number of printer pages, and number of cards which may be generated from the run. Plotter-ID gives the logical ID of the CalComp pen plotter and file is the file which contains the absolute element of the STACOM program. Printer-ID gives the logical ID of the regular printer. DATA as shown is the input data described in Paragraph 3.2.1; the user should arrange the data in the same order. When all of these data items are in order and ready, the deck can be submitted to the operator at the computer site for processing.

3.3.3.1.2 Demand Mode. If program execution is to be performed via a demand terminal, the user can converse interactively with the program. The user may also run the program as a batch job by having all input data prepared and added after the @XQT statement.

Under the conversation mode, the user acts as a respondent who answers the requests for data made by the program. This mode of operation provides the user with some understanding of program progress. A user can very often terminate a run before a complete set of input data is given. This is possible because the user has some knowledge of the progress being made. This capability can prevent the user from an unnecessary waste of time. For example, if a run encounters a system which has more oversized distance data than allowed, a message from the program will be printed out on the terminal. The user will be alarmed by this fact and may decide to terminate the program run.

3.3.3.2 Run Progression. After receiving all of the required data, the program will perform all functions as designed and requested by the user whether a batch or a demand job has been executed. The program will perform formation of regions, selection of regional switching centers, formation of a regional star network and its optimization if requested, and finally, formation and optimization of an interregional network. All of the desired output data will go to the alternate file, 100.

3.3.3.3 Normal Termination. When a STACOM program run proceeds successfully and terminates normally, the normal file unit 6 will contain two lines of messages for each successful regional network optimization. These two lines are:

- (1) TRYLNK has been accessed for xxxxx times.
- (2) UPNETW has been accessed for xxxxx times.

The first message indicates the number of subroutine calls to TRYLNK that have been made during the process of searching for a better network. The second message indicates the number of optimization cycles which the run has gone through before the optimization process stops. After a normal termination, the user can direct the output file 100 to a printer device and the punch card file to a CalComp pen plotter if file PUNCH\$ has been directed to an alternate file.

3.3.3.4 Aborting and Recovering a Run. When a run encounters trouble resulting from incorrect input data, the user can use the normal aborting procedure to terminate its execution if it is a demand job. A statement of @@x after interrupting the line communication by pressing the BREAK key will terminate a program execution at any time. On the other hand, the EXEC-8 may abort a program execution when certain serious violations occur during its execution, e.g., number of punch cards exceeding the limit on the run card.

If a program run has been interrupted due to system outage, no recovery of the run is possible.

3.3.4 Program Listing

A listing of the STACOM program elements is given in Appendix A.

3.4 SAMPLE RUN

To illustrate how STACOM can be run, a sample run is provided in the following subsections along with detailed explanations.

3.4.1 run Stream

The following list of control statements shows the typical batch mode run stream used to execute the STACOM program.

```
@RUN JJJ,J6G3YL,51928,20,90/1000
@ASC,UP 100
@SYM,P PUNCH$,G9PLTF
@XQT LEE.STACOM
@ADD LEE.DATA
@BRKPT 100
@FREE 100
@SYM,U 100,,T4
@FIN
```

The first control statement is a run request which specifies its run ID as JJJ, identifies its account number as J6G3YL, assigns project ID as 51928, requests a maximum of 20 minutes of SUP-time and finally asks for a limit of 90 printer pages and 1,000 punch cards. The limits on SUP-time, number of printer pages and number of punch cards deserve some attention when making a run. If there is an underestimate in any of these three limits, the run may abort due to insufficient resource assignment.

The second statement is used to assign an alternate FORTRAN output file as required by the program. It is intended to be a one-day file.

Statement 3 requests the system to direct the punch card image file to the CalComp pen plotter with the name G9PLTF.

Statement 4 is a command for executing the STACOM program which is designated with the element name STACOM in file LEE.

The next statement asks the operating system to use the content of element DATA as its input data.

Statements 6 and 7 are used to close file 100 and catalog it for later use.

Statement 8 asks the operating system to send the printer file 100 to an on-site low speed printer with ID T4. The U option retains the FORTRAN print file after a copy is printed

The last statement terminates the run with a request for a detailed description of run charges and run history. The number of pages in the print file and the number of punch-card images are part of the data given by the accounting subsystem when a run terminates.

When the same program is to be executed via a demand terminal, the content of element LEE.DATA can be divided into several individual elements plus certain key-in control statements. Essentially, however, the same amount of input data must be provided to succeed in running the program.

3.4.2 Input

As a specific example, Table 3-2 gives the list of data which have been used in analyzing the South Plains portion of Texas under the Council-of-Governments structure.

Encircled numbers have been written on the left hand side so that Table 3-2 and Table 3-1 are made compatible. Data associated with each encircled number in Table 3-2 corresponds to the data item with the same index in Table 3-1. Items 1 and 2 indicate that the run is concerned with 1 region case, a total of 25 system terminations, 4 data bases, and a total of 358 distinctive cities. Items 3 gives the IDs for locations of those four data bases, and item 4 lists the names of all 358 cities which have distinctive V-H coordinates (four digit integers). Since the number of data bases is greater than 2, two input cards are needed for each system termination; therefore a total of 50 cards are needed as listed under item 5. Since there is only one rate structure, one card is needed for rate application matrix (see items 6 and 7).

Item 8 shows the traffic density and rate application table for which 9 cards are required. Items 9 and 10 indicate that only 3 type of lines (with rates 1200 bps, 2400 bps, and 4800 bps) are considered; 0.7 is the line utilization limit for all of them. Three chargeable items are applicable as shown in items 11 and 12. Item 13 is somewhat complicated, the following explanation should enable the reader to understand it. These 108 data cards are divided into 3 groups with the first group given to the first line type, i.e., 1200 bps, and so on.

Table 3-2. Input Data for the Example Run

51928*STACOM(0).INPUT/0777

1	① → 1			
2	② → 25	4	358	
3	③ → AAAA DDDD SSSS HHHH			
4	④ → PALESTINE	ANDERSON	8558	3750
5	ANDREWS	ANDREWS	8897	4993
6	LUFKIN	ANGELINA	8575	3561
7	ROCKPORT	ARANSAS	9405	3694
8	ARCHER CITY	ARCHER	8396	4410
9	JOUPDANTON	ATASCOSA	9332	4032
10	BELLVILLE	AUSTIN	8964	3710
11	MULESHOE	BATLEY	8518	5157
12	SEYMOUR	BAYLOR	8437	4518
13	BEEVILLE	BFF	9378	3850
14	BELTON	BELL	8827	4010
15	FORT HOOD	BFL	8832	4070
16	HARKER HEIGHTS	BFL	8832	4063
17	KILLEEN	BELL	8832	4063
18	NOLANVILLE	BELL	8832	4038
19	TEMPLE	BELL	8812	3992
20	ALAMO HEIGHTS	BEXAR	9225	4062
21	FT SAM HOUSTON	BEXAR	9225	4062
22	LEON VALLEY	BEXAR	9223	4092
23	SAN ANTONIO	BEXAR	9225	4062
24	UNIVERSAL CITY	BEXAR	9187	4037
25	CLIFTON	BOSQUE	8690	4089
26	MERIDIAN	BOSQUE	8668	4112
27	TEXARKANA	BOWIE	8111	3626
28	ALVIN	BRAZORIA	8996	3488
29	ANGLETON	BRAZORIA	9059	3499
30	CLUTE	BRAZORIA	9081	3487
31	FREEPOR	BRAZORIA	9096	3466
32	LAKE JACKSON	BRAZORIA	9081	3487
33	PEARLAND	BRAZORIA	8970	3506
34	BRYAN	BRAZOS	8827	3788
35	COLLEGE STATION	BRAZOS	8827	3788
36	ALPINE	BREWSTER	9364	5057
37	FALFURRIAS	BROOKS	9645	3927
38	BROWNWOOD	BROWN	8797	4327
39	CALDWELL	BURLESON	8880	3834
40	PORT LAVACA	CALHOUN	9258	3665
41	BROWNSVILLE	CAMERON	9861	3606
42	HAPLINGEN	CAMERON	9820	3663
43	PORT ISABEL	CAMERON	9807	3565
44	SAN BENITO	CAMERON	9826	3648
45	LINDEN	CASS	8217	3643
46	DIMIT	CASTRO	8427	5109
47	ANAHUAC	CHAMBERS	8884	3418
48	JACKSONVILLE	CHEROKEE	8492	3709
49	CHILDRESS	CHILDRESS	8328	4743
50	MORTON	COCHRAN	8622	5129
51	ROBERT LEE	COKE	8857	4603
52	COLEMAN	COLEMAN	8804	4413
53	FRISCO	COLLIN	8364	4069
54	MCKINNEY	COLLIN	8340	4038
55	PLANO	COLLIN	8383	4037
56	WELLINGTON	COLLINGSWH	8240	4776

Table 3-2. Input Data for the Example Run
(Continuation 1)

57	COLUMBUS	COLORADO	9032	3740
58	NEW BRAUNFELS	COMAL	9145	4018
59	COMANCHE	COMANCHE	8735	4275
60	GAINESVILLE	COOKE	8289	4162
61	COPPERAS COVE	CORYELL	8844	4002
62	GATESVILLE	CORYELL	8771	4089
63	CRANE	CRANE	9073	4896
64	OZONA	CROCKETT	9144	4642
65	DALHART	DALLAM	8129	5249
66	ADDISON	DALLAS	8404	4048
67	CEDAR HILL	DALLAS	8485	4047
68	DALLAS	DALLAS	8436	4034
69	DESOTO	DALLAS	8478	4030
70	DUNCANVILLE	DALLAS	8469	4044
71	FARMERS BRANCH	DALLAS	8414	4062
72	GARLAND	DALLAS	8400	4018
73	GRAND PRAIRIE	DALLAS	8458	4066
74	HIGHLAND PARK	DALLAS	8436	4034
75	IRVING	DALLAS	8440	4064
76	LANCASTER	DALLAS	8470	4013
77	MESQUITE	DALLAS	8426	4000
78	RICHARDSON	DALLAS	8399	4035
79	SEAGOVILLE	DALLAS	8447	3980
80	UNIVERSITY PARK	DALLAS	8436	4034
81	LAMESA	DAWSON	8779	4919
82	HEREFORD	DEAF SMTH	8378	5143
83	DENTON	DENTON	8372	4127
84	LEWISVILLE	DENTON	8398	4089
85	CUERO	DEWITT	9209	3823
86	SPUR	DICKENS	8560	4784
87	SAN DIEGO	DUVAL	9542	3888
88	EASTLAND	EASTLAND	8649	4352
89	ODESSA	ECTOR	8982	4930
90	ENNIS	ELLIS	8514	3970
91	WAXAHACHIE	ELLIS	8517	4011
92	EL PASO	EL PASO	9231	5655
93	STEPHENVILLE	ERATH	8645	4232
94	MARLIN	FALLS	8739	3931
95	BONHAM	FANNIN	8234	3906
96	RORY	FISHER	8679	4646
97	FLOYDADA	FLOYD	8486	4902
98	FAIRFIELD	FREESTONE	8602	3839
99	PEARSALL	FRIO	9374	4129
100	RICHMOND	FT BEND	9009	3598
101	ROSENBERG	FT BEND	9009	3598
102	SEMINOLE	GAINES	8822	5040
103	FRIENDSWOOD	GALVESTON	8969	3489
104	GALVESTON	GALVESTON	8985	3397
105	HITCHCOCK	GALVESTON	8992	3441
106	LA MARQUE	GALVESTON	8975	3424
107	LEAGUE CITY	GALVESTON	8967	3468
108	TEXAS CITY	GALVESTON	8975	3424
109	POST	GARZA	8650	4854
110	FREDERICKSBURG	GILLESPIE	9079	4196
111	GOLIAD	GOLIAD	9301	3807
112	GONZALES	GONZALES	9137	3884
113	PAMPA	GRAY	8148	4952

Table 3-2. Input Data for the Example Run
(Continuation 2)

114	DENISON	GRAYSON	8225	4069
115	SHERMAN	GRAYSON	8253	4072
116	GLADEWATER	GREGG	8354	3698
117	KILGORE	GREGG	8379	3674
118	LONGVIEW	GREGG	8348	3660
119	NAVASOTA	GRIMES	8865	3715
120	SEGUIN	GUADALUPE	9161	3981
121	PLAINVIEW	HALE	8465	4981
122	HAMILTON	HAMILTON	8744	4177
123	SPEARMAN	HANSFORD	8026	5037
124	QUANAH	HARDEMAN	8324	4654
125	KOINTZE	HARDIN	8735	3405
126	SILSBEE	HARDIN	8730	3380
127	BAYTOWN	HARRIS	8916	3466
128	BELLAIRE	HARRIS	8938	3536
129	DEEP PARK	HARRIS	8929	3491
130	GALENA PARK	HARRIS	8938	3536
131	HOUSTON	HARRIS	8938	3536
132	HUMBLE	HARRIS	8881	3540
133	JACINTO CITY	HARRIS	8938	3536
134	JERSEY VILLAGE	HARRIS	8925	3581
135	KATY	HARRIS	8965	3618
136	LA PORTE	HARRIS	8829	3470
137	PASADENA	HARRIS	8938	3536
138	SEABROOK	HARRIS	8945	3462
139	SOUTH HOUSTON	HARRIS	8938	3536
140	SOUTHSIDE PLACE	HARRIS	8938	3536
141	SPRING VALLEY	HARRIS	8938	3536
142	TOMBALL	HARRIS	8889	3609
143	VILLAGE	HARRIS	8938	3536
144	WEBSTER	HARRIS	8967	3468
145	WEST UNIV PL	HARRIS	8938	3536
146	MARSHALL	HARRIS	8311	3602
147	HASKELL	HASKELL	8555	4567
148	SAN MARCOS	HAYS	9096	4001
149	CANADIAN	HEMPHILL	8036	4882
150	ATHENS	HENDERSON	8484	3826
151	DONNA	HIDALGO	9849	3728
152	EDINBURG	HIDALGO	9830	3758
153	HIDALGO	HIDALGO	9856	3764
154	MCALLEN	HIDALGO	9856	3764
155	MERCEDES	HIDALGO	9845	3701
156	MISSION	HIDALGO	9861	3781
157	PHARR	HIDALGO	9854	3754
158	WESLACO	HIDALGO	9847	3716
159	HILLSBORO	HILL	8612	4026
160	LEVELLAND	HOCKLEY	8629	5053
161	SULPHUR SPRINGS	HOPKINS	8281	3861
162	BIG SPRING	HOWARD	8847	4900
163	COMMERCE	HUNT	8280	3921
164	GREENVILLE	HUNT	8317	3949
165	BORGER	HUTCHINSON	8146	5033
166	JACKSBORO	JACK	8442	4303
167	EDNA	JACKSON	9186	3698
168	BEAUMONT	JEFFERSON	8777	3344
169	NEEDERLAND	JEFFERSON	8789	3316
170	PORT ARTHUR	JEFFERSON	8806	3298

Table 3-2. Input Data for the Example Run
(Continuation 3)

171	ALICE	JIM WELLS	9533	3855
172	BURLESON	JOHNSON	8522	4103
173	CLFURNE	JOHNSON	8563	4102
174	ANSON	JONES	8647	4563
175	STAMFORD	JONES	8603	4562
176	KARNES CITY	KARNES	9294	3915
177	KAUFMAN	KAUFMAN	8442	3936
178	TERRELL	KAUFMAN	8410	3943
179	BOERNE	KENDALL	9168	4133
180	JAYTON	KENT	8589	4718
181	KERRVILLE	KERR	9143	4226
182	JUNCTION	KIMBLE	9097	4373
183	KINGSVILLE	KLEBERG	9566	3801
184	BENJAMIN	KNOX	8472	4609
185	PARIS	LAMAR	8173	3897
186	LITTLEFIELD	LAMB	8558	5060
187	OLTON	LAMB	8490	5054
188	LAMPASAS	LAMPASAS	8875	4137
189	HALLETTSVILLE	LAVACA	9114	3789
190	YOAKUM	LAVACA	9157	3814
191	CENTERVILLE	LEON	8682	3768
192	CLFVELAND	LIBERTY	8801	3540
193	LIBERTY	LIBERTY	8835	3463
194	MEYTA	LIMESTONE	8635	3889
195	GEORGE WEST	LIVE OAK	9419	3910
196	LUBROCK	LUBROCK	8598	4962
197	SLATON	LUBROCK	8616	4916
198	TAHOKA	LYNN	8680	4924
199	MADISONVILLE	MADISON	8740	3733
200	JEFFERSON	MARION	8267	3618
201	BAY CITY	MATAGORDA	9135	3578
202	EAGLE PASS	MAVERICK	9505	4370
203	BRADY	MCCULLOCH	8938	4344
204	BELLMEAD	MCLENNAN	8706	3993
205	BEVERLY HILLS	MCLENNAN	8706	3993
206	WACO	MCLENNAN	8706	3993
207	WOODWAY	MCLENNAN	8706	3993
208	HONDO	MEDINA	9285	4174
209	MENARD	MENARD	9011	4407
210	MIDLAND	MIDLAND	8934	4888
211	CAMFRON	MILAM	8835	3910
212	ROCKDALE	MILAM	8877	3898
213	COLORADO CITY	MITCHELL	8781	4706
214	BOWIE	MONTAGUE	8351	4275
215	MONTAGUE	MONTAGUE	8323	4261
216	CONROE	MONTGOMRY	8832	3600
217	DUMAS	MOORE	8141	5144
218	DAINGERFIELD	MORRIS	8240	3704
219	NACOGDOCHES	NACOGDOCHES	8515	3569
220	CORSICANA	NAVARRO	8553	3921
221	SWEETWATER	NOLAN	8737	4632
222	CORPUS CHRISTI	NUECES	9475	3739
223	ROSTOWN	NUECES	9496	3786
224	PERRYTON	OCHILTREE	7962	4987
225	VEGA	OLDHAM	8292	5177
226	ORANGE	ORANGE	8746	3281
227	MINERAL WELLS	PARKEP	8520	4261

Table 3-2. Input Data for the Example Run
(Continuation 4)

228	CARTHAGE	PANOLA	8385	3564
229	WEATHERFORD	PARKER	8508	4206
230	FARWELL	PARMER	8503	5221
231	FRIONA	PARMEP	8432	5185
232	FOPT STOCKTON	PECOS	9207	4954
233	AMARILLO	POTTER	8266	5076
234	CANYON	RANDALL	8317	5075
235	CLARKSVILLE	RED RIVER	8147	3809
236	PECOS	REEVES	9136	5101
237	BIG LAKE	REGAN	9062	4723
238	HEARNE	ROBERTSON	8802	3846
239	ROCKWALL	ROCKWALL	8384	3989
240	BALLINGER	RUNNELS	8855	4498
241	HENDERSON	RUSK	8420	3640
242	ARANSAS PASS	SAN PTRCO	9437	3700
243	GREGORY	SAN PTRCO	9455	3731
244	INGLESIDE	SAN PTRCO	9447	3711
245	PORTLAND	SAN PTRCO	9455	3731
246	SINTON	SAN PTRCO	9436	3777
247	ELDORADO	SCHLEICHR	9076	4547
248	SNYDER	SCURRY	8718	4737
249	STRATFORD	SHERMAN	8049	5194
250	TYLER	SMITH	8417	3744
251	BRECKENRIDGE	STEPHENS	8582	4394
252	STERLING CITY	STERLING	8900	4686
253	ASPERMONT	ST. NEWALL	8589	4650
254	TULIA	SWISHER	8397	5016
255	ARLINGTON	TARRANT	8472	4085
256	BEDFORD	TARRANT	8447	4092
257	COLLEYVILLE	TARRANT	8447	4117
258	CROWLEY	TARRANT	8518	4118
259	EULESS	TARRANT	8447	4092
260	FORREST HILL	TARRANT	8479	4122
261	FORT WORTH	TARRANT	8479	4122
262	GRAPEVINE	TARRANT	8425	4094
263	HALTOM CITY	TARRANT	8479	4122
264	HURST	TARRANT	8447	4117
265	LAKE WORTH	TARRANT	8471	4158
266	NO RICHLAND HLS	TARRANT	8447	4117
267	RICHLAND HILLS	TARRANT	8479	4122
268	SOUTHLAKE	TARRANT	8425	4094
269	WHITE SETTLMNT	TARRANT	8485	4153
270	ABILENE	TAYLOR	8698	4513
271	SANDERSON	TERRELL	9333	4816
272	BROWNFIELD	TERRY	8705	5007
273	MT PLEASANT	TITUS	8234	3755
274	SAN ANGELO	TOM GREEN	8944	4563
275	AUSTIN	TRAVIS	9005	3996
276	GILMER	UPSHUR	8317	3716
277	RANKIN	UPTON	9084	4811
278	UVALDE	UVALDE	9357	4279
279	DEL RIO	VAL VERDE	9399	4490
280	CANTON	VAN ZANDT	8414	3858
281	VICTORIA	VICTORIA	9245	3748
282	HUNTSVILLE	WALKER	8758	3652
283	HEMPSTEAD	WALLER	8923	3691
284	MONAHANS	WARD	9066	5005

Table 3-2. Input Data for the Example Run
(Continuation 5)

285	BRENHAM	WASHINGTON	8932	3752
286	LAREDO	WEBB	9681	4099
287	PIERCE	WHARTON	9115	3649
288	WHARTON	WHARTON	9078	3630
289	SHAMROCK	WHEELER	8170	4808
290	BURKBURNETT	WICHITA	8290	4440
291	WICHITA FALLS	WICHITA	8326	4413
292	VERNON	WILBARGER	8326	4567
293	RAYMONDVILLE	WILLACY	9768	3703
294	FLORESVILLE	WILSON	9261	3979
295	KERMIT	WINKLER	9024	5060
296	DECATUR	WISE	8399	4205
297	WINNSBORO	WOOD	8295	3794
298	DENVER CITY	YOAKUM	8781	5088
299	GRAHAM	YOUNG	8492	4365
300	OLNEY	YOUNG	8450	4414
301	CRYSTAL CITY	ZAVALA	9466	4246
302	ARANSAS PASS	ARANSAS	9437	3700
303	PLEASANTON	ATASCOSA	9320	4027
304	BANDERA	BANDERA	9205	4190
305	BASTROP	BASTROP	9007	3909
306	MARBLE FALLS	BURNET	8980	4115
307	LOCKHART	CALDWELL	9077	3954
308	LULING	CALDWELL	9117	3933
309	BAIRD	CALLAHAN	8688	4450
310	PITTSBURG	CAMP	8264	3742
311	PANHANDLE	CARSON	8210	5009
312	ATLANTA	CASS	8182	3618
313	RUSK	CHEROKEE	8515	3672
314	HENRIETTA	CLAY	8323	4354
315	CROSBYTON	CROSBY	8548	4862
316	CARROLLTON	DALLAS	8410	4066
317	COOPER	DELTA	8241	3896
318	CARRIZO SPRS.	DIMMIT	9500	4240
319	CISCO	EASTLAND	8662	4377
320	LA GRANGE	FAYETTE	9016	3813
321	MT VERNON	FRANKLIN	8246	3801
322	ANDERSON	GRIMES	8836	3708
323	MEMPHIS	HALL	8287	4821
324	ALAMO	HIDALGO	9854	3754
325	GRANBURY	HOOD	8572	4178
326	CROCKETT	HOUSTON	8634	3685
327	STINNETT	HUTCHINSON	8117	5054
328	JASPER	JASPER	8603	3399
329	GROVES	JEFFERSON	8789	3316
330	PORT NECHES	JEFFERSON	8789	3316
331	COTULLA	LASALLE	9476	4120
332	GIDDINGS	LEE	8968	3848
333	GROESBECK	LIMESTONE	8671	3886
334	LLANO	LLANO	8970	4199
335	NEWTON	NEWTON	8600	3353
336	BRIDGE CITY	ORANGE	8774	3295
337	VINOR	ORANGE	8761	3334
338	PALO PINTO	PLO PINTO	8541	4291
339	LIVINGSTON	POLK	8716	3543
340	REFUGIO	REFUGIO	9365	3757
341	FRANKLIN	ROBERTSON	8766	3839

Table 3-2. Input Data for the Example Run
(Continuation 6)

342	HEMPHILL	SARINE	8511	3413			
343	SAN AUGUSTINE	SN AUGUST	8491	3471			
344	COLDSPRING	SN JACINT	8754	3567			
345	SAN SABA	SAN SABA	8886	4242			
346	MATHIS	SAN PTRCO	9448	3840			
347	CENTER	SHELBY	8443	3505			
348	RIO GRANDE CTY	STARR	9861	3887			
349	BENBROOK	TARRANT	8499	4140			
350	EVERMAN	TARRANT	8505	4110			
351	RIVEROAKS	TARRANT	8479	4122			
352	GROVETON	TRINITY	8661	3605			
353	WOODVILLE	TYLER	8664	3458			
354	EL CAMPO	WHARTON	9115	3649			
355	WHEELER	WHEELER	8126	4829			
356	IOWA PARK	WICHITA	8327	4445			
357	GEORGETOWN	WILLIAMSO	8927	4014			
358	TAYLOR	WILLIAMSO	8922	3962			
359	QUITMAN	WOOD	8340	3806			
360	PLAINES	YOAKUM	8735	5105			
361	ZAPATA	ZAPATA	9786	4009			
362	⑨ → AZLI MULESHOE PD		A	7.35	19.23	.00	.00
363	.00	.00		.00			
364	AZKK MORTON SO	.00	47	4.38	10.58	.00	.00
365	.00	.00		.00			
366	AZKW SPUR PD	.00	83	6.28	17.80	.00	.00
367	.00	.00		.00			
368	AZX7 FLOYDADA SO	.00	94	5.60	11.91	.00	.00
369	.00	.00		.00			
370	AZLQ POST SO	.00	106	2.86	8.16	.00	.00
371	.00	.00		.00			
372	AZLA PLAINVIEW PD	.00	118	25.27	55.61	.00	.00
373	.00	.00		.00			
374	AZLR PLAINVIEW SO	.00	118	7.67	14.67	.00	.00
375	.00	.00		.00			
376	AZLD LEVELLAND PD	.00	157	10.45	27.80	.00	.00
377	.00	.00		.00			
378	AZLC LITTLEFIELD PD	.00	183	8.87	21.94	.00	.00
379	.00	.00		.00			
380	AZKA LITTLEFIELD SO	.00	183	4.57	11.05	.00	.00
381	.00	.00		.00			
382	AZTI OLTON PD	.00	184	5.36	16.01	.00	.00
383	.00	.00		.00			
384	AZGL LURBOCK DPS	.00	193	31.12	98.55	.00	.00
385	.00	.00		.00			
386	AZLK LURBOCK PD	.00	193	242.28	340.68	.00	.00
387	.00	.00		.00			
388	AZLL LURBOCK SO	.00	193	39.61	59.13	.00	.00
389	.00	.00		.00			
390	AZLR SLATON PD	.00	194	10.01	23.71	.00	.00
391	.00	.00		.00			
392	AZLJ TAHOKA PD	.00	195	5.72	17.21	.00	.00
393	.00	.00		.00			
394	AZKS TAHOKA SO	.00	195	4.03	9.94	.00	.00
395	.00	.00		.00			
396	AZLF BROWNFIELD PD	.00	269	17.09	40.89	.00	.00
397	.00	.00		.00			
398	AZLF BROWNFIELD SO	.00	269	4.03	8.36	.00	.00

Table 3-2. Input Data for the Example Run
(Continuation 7)

[illegible]

Table 3-2. Input Data for the Example Run
(Continuation 8)

456	10.	10.
457	0.	0.
458	0.	0.
459	10.	10.
460	10.	10.
461	0.	0.
462	0.	0.
463	10.	10.
464	10.	10.
465	10.	10.
466	10.	10.
467	15.	15.
468	15.	15.
469	10.	10.
470	10.	10.
471	15.	15.
472	15.	15.
473	10.	10.
474	10.	10.
475	15.	15.
476	15.	15.
477	100.	100.
478	100.	100.
479	54.	54.
480	54.	54.
481	100.	100.
482	100.	100.
483	54.	54.
484	54.	54.
485	100.	100.
486	100.	100.
487	54.	54.
488	54.	54.
489	0.	0.
490	0.	0.
491	10.	10.
492	10.	10.
493	0.	0.
494	0.	0.
495	10.	10.
496	10.	10.
497	0.	0.
498	0.	0.
499	10.	10.
500	10.	10.
501	10.	10.
502	10.	10.
503	15.	15.
504	15.	15.
505	10.	10.
506	10.	10.
507	15.	15.
508	15.	15.
509	10.	10.
510	10.	10.
511	15.	15.
512	15.	15.

Table 3-2. Input Data for the Example Run
(Continuation 9)

513	100.	100.							
514	100.	100.							
515	135.	135.							
516	135.	135.							
517	100.	100.							
518	100.	100.							
519	135.	135.							
520	135.	135.							
521	100.	100.							
522	100.	100.							
523	135.	135.							
524	135.	135.							
525	0.	0.							
526	0.	0.							
527	10.	10.							
528	10.	10.							
529	0.	0.							
530	0.	0.							
531	10.	10.							
532	10.	10.							
533	0.	0.							
534	0.	0.							
535	10.	10.							
536	10.	10.							
537	(14) → 1	QLINEAR FOR 1200 BAUD LINE							
538	900.	.0	900.	.0					
539	1.	3.	1.	3.					
540	900.	.0	900.	.0					
541	1.	3.	1.	3.					
542	900.	.0	900.	.0					
543	1.	.6	1.	.0					
544	1	QLINEAR FOR 2400 BAUD LINE							
545	900.	.0	900.	.0					
546	1.	3.	1.	3.					
547	900.	.0	900.	.0					
548	1.	3.	1.	3.					
549	900.	.0	900.	.0					
550	1.	.6	1.	.0					
551	1	QLINEAR FOR 4800 BAUD LINE							
552	900.	.0	900.	.0					
553	1.	3.	1.	3.					
554	900.	.0	900.	.0					
555	1.	3.	1.	3.					
556	900.	.0	900.	.0					
557	1.	.6	1.	.0					
558	(15) → 1 2								
559	0 0								
560	(16) → 3	2	0	0	8 .008	.0			
561	3	2	0	0	8 .008	.0			
562	3	2	0	0	8 .050	.0			
563	(17) → 11								
564	(18) → LIDR	35	300	4.26	3.94	0	0	.0	.0
565	TCIC	60	8615.25	14.47		0	0	.0	.0
566	ADM	500	500	3.62	3.62	0	0	.0	.0
567	G-CODE	300	300	.13	8.43	0	0	.0	.0
568	CCH	426	459	5.78	5.78	0	0	.0	.0
569	MVD	50	175	9.34	9.34	0	0	.0	.0

Table 3-2. Input Data for the Example Run
(Continuation 10)

570	ING/NL	50	200	.45	.45	0	0	.0	.0
571	ADM/NL	300	300	.45	.0	0	0	.0	.0
572	NCIC	50	90	.0	9.21	0	0	.0	.0
573	DB/DLS	90	50	3.49	1.1	0	0	.0	.0
574	DB/ANT	90	50	.45	.45	0	0	.0	.0
575	(19) → .110								
576	(20) → 2 AAAA					1			QSWITCHER ASSINGMENT WITH I1,I4,A4,I5
577	3								QTERMINATE SWITCHER ASSIGNMENT
578	(21) → AAAA								QSTATE CENTER
579	(22) → 6.43					2			QTOTAL XSAC & REQ. AT THE AUSTIN SWITCHER WITH F8.5 A13
580	(23) → 20 7.0					1			QTERM./LINE/RESP. TIME, MPROC WITH I3,F5.2,I2
581	(24) → 1								Q1 FOR PLOTTING AND 0 FOR SKIPPING IT WITH I3

CPU:.787 CTP:.091 SUPS:17.904

QBRKPT PRINTS

Each group is then divided into three subgroups of 12 cards, one for each chargeable item. Each subgroup is then divided into 3 units, 4 cards per unit, according to the three types of traffic density combinations: high-high, high-low and low-low. Each specific unit is then divided into two subunits of 2 cards. The first subunit is for installation costs, and the second for recurring costs. The first card of each subunit is for costs under half duplexing mode, and the second for costs under full duplexing mode. The first number of each card is the cost for the initial unit; the second for each additional unit at the same location.

Item 14 indicates that, in Texas, a linear costing function is used for all of the line service charges. The first card gives the installation charge as a function of distance, and the second the monthly recurring charge as a function of distance. Under each line type, the line cost is also given as a function of traffic density mix between two terminals.

Item 15 indicates that an optimization process is requested after a star network is formed.

Item 16 shows the line protocol characteristics for those three line types under consideration by providing data such as no. of polling characters, modem turn-around time, while item 17 and 18 give the message statistics. Item 19 indicates that a 110 milli-second is used as the average transaction service time needed in the central switcher of the system being studied.

Item 20 pre-selects system termination AAAA as the RSC, and item 21 designates AAAA as the system centroid.

The three remaining cards define the total traffic load at the central switcher, the multidrop line constraints, and a request for a CalComp plot at the end of each regional network optimization.

3.4.3 Output

After a normal termination from a STACOM program run, outputs from the printer and the CalComp plotter should contain all data desired. This subsection describes the contents of these outputs obtained from the example run.

3.4.3.1 Printer Output. Data showing results from a normal program execution of the STACOM program are printed on a regular printer. Table 3-3 shows the exact output obtained from running the STACOM program utilizing the set of input data as given in Paragraph 3.4.2.

To facilitate the following discussions, the contents of Table 3-3 are itemized as shown.

Item 1 reminds the user that only one region has been considered in this specific run. Item 2 shows the line protocol for each

Table 3-3. Printer Output from the Example Run

① → THERE ARE 1 REGIONS

② → 1200 POLL CHAR.= 3 NAK CHAR.= 2 POLL O/H= 0
 NAK O/H= 0 MSG O/H= 8
 MPSEM= .008 PPSEM= .000

2400 POLL CHAR.= 3 NAK CHAR.= 2 POLL O/H= 0
 NAK O/H= 0 MSG O/H= 8
 MPSEM= .008 PPSEM= .000

4800 POLL CHAR.= 3 NAK CHAR.= 2 POLL O/H= 0
 NAK O/H= 0 MSG O/H= 8
 MPSEM= .050 PPSEM= .000

③ → AVG. INPUT MSG WITH PRIO 1= 147.0 CHARS
 AVG. INPUT MSG 147.0 CHARS
 AVG. OUTPUT MSG W/H PRIO 1= 212.2 CHARS.
 AVG. OUTPUT MSG WITH PRIO2= .0 CHARS
 OVERALL AVG. MSG = 184.0 CHARS

④ → 2 AAAA 1
 3 0

⑤ →

TRAFFIC MATRIX(RPS)															
TERM.	AZLI	AZKK	AZKW	AZXZ	AZLQ	AZLA	AZLR	AZLD	AZLC	AZKA	AZTI	AZGL	AZLK	AZLL	AZLF
TRAFIN	1.0	.6	.8	.7	.4	3.4	1.0	1.4	1.2	.6	.7	4.1	32.3	5.3	1.9
TRFOUT	2.6	1.4	2.4	1.6	1.1	7.4	2.0	3.7	2.9	1.5	2.1	13.1	45.4	7.9	3.2
TRAFIN	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TRFOUT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TRAFIN	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TRFOUT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TRAFIN	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TRFOUT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

Table 3-3. Printer Output from the Example Run
(Continuation 1)

⑥ → TOTAL TRAFFIC ORIGINATED FROM SYS. TERM. (BITS/SEC)									
AZLI	.980	AZKK	.584	AZKW	.837	AZYZ	.747	AZLO	.381
AZLA	3.369	AZLB	1.023	AZLD	1.393	AZLC	1.183	AZKA	.600
AZTI	.715	AZGL	4.149	AZLF	32.304	AZIL	5.281	AZLR	1.335
AZLJ	.763	AZKS	.517	AZLE	2.279	AZLF	.537	AZLN	.985
NAAF	.221	NAAG	.221	NAAG	.357	NAFA	.204	AAAA	.000
TOTAL TRAFFIC= 61.00									
TOTAL TRAFFIC DESTINATED TO SYS. TERM. (BITS/SEC)									
AZLI	2.564	AZKK	1.411	AZKW	2.373	AZYZ	1.584	AZLO	1.000
AZLA	7.415	AZLB	1.054	AZLD	3.707	AZLC	2.425	AZKA	1.473
AZTI	2.135	AZGL	13.140	AZLF	45.424	AZIL	7.880	AZLR	3.161
AZLJ	2.295	AZKS	1.325	AZLE	5.452	AZLF	1.115	AZLN	2.783
NAAE	.701	NAAG	.701	NAAG	1.131	NAFA	.608	AAAA	.000
TOTAL TRAFFIC= 119.30									
TOTAL SYSTEM TRAFFIC= 175.30									

Table 3-3. Printer Output from the Example Run
(Continuation 2)

① →

POINT TO POINT DISTANCE MATRIX															
TERM.	AZLR	AZLL	AZLK	AZGL	AZTI	AZKA	AZLC	AZLD	AZLH	AZLA	AZLO	AZXZ	AZKW	AZKK	AZLI
AZLI	83.	67.	67.	67.	34.	31.	31.	49.	59.	59.	105.	82.	119.	75.	
AZKK	68.	54.	54.	54.	44.	24.	24.	25.	69.	69.	88.	89.	111.		
AZKW	46.	58.	58.	58.	80.	01.	01.	88.	70.	70.	37.	85.			
AZXZ	42.	41.	41.	41.	44.	54.	54.	66.	26.	26.	55.				
AZLO	23.	38.	38.	38.	81.	74.	74.	64.	71.	71.					
AZLA	52.	43.	43.	43.	25.	41.	41.	57.	0.						
AZLB	52.	43.	43.	43.	24.	41.	41.	57.							
AZLD	44.	31.	31.	31.	48.	24.	24.								
AZLC	52.	37.	37.	37.	23.	0.									
AZKA	52.	37.	37.	37.	23.										
AZTI	60.	45.	45.	45.											
AZGL	16.	0.	0.												
AZLK	16.	0.													
AZLL	16.														
AZLR	0.														

② → MCC= AAAA

③ → CPU UTILIZATION PER PROCESSOR IS .707

④ → REG= 1 , SYS. TERM.=

AZLI MULESHOE PD	AZKK MORTON SO	AZY / SPIR PD	AZXZ FLOYDANA SO
AZLO POST SO	AZLA PLAINVIEW PD	AZLB PLAINVIEW SO	AZLD LEVELLAND PD
AZLC LITTLEFIELD PD	AZKA LITTLEFIELD SO	AZTI OLTON PD	AZGL LIMBROCK DRS
AZLK LUBBOCK PD	AZLL LUBBOCK SO	AZLR SLATON PD	AZLJ TAHOKA PD
AZKS TAHOKA SO	AZLE BROWNFIELD PD	AZLF BROWNFIELD SO	AZLH DENVER CITY PD
NAAE MULESHOE S.O.	NAHG CROSBY S.O.	NACG LEVFLAND S.O.	NAFA PLAINES S.O.
AAAA AUSTIN SWITCHER			

INDICES FOR SYS. TERM.=

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

⑤ → RSC= AAAA FOR REGION 1

Table 3-3. Printer Output from the Example Run
(Continuation 3)

REGIONAL STAR NETWORK AND ITS COSTS- 1										
SYSTEM TERMN.	AZLI	AZKK	AZKH	AZXZ	AZLQ	AZLA	AZLM	AZLO	AZLC	AZKA
NO. OF LINES RFD.										
1.2KB	1	1	1	1	1	1	1	1	1	1
2.4KB	0	0	0	0	0	0	0	0	0	0
4.8KB	0	0	0	0	0	0	0	0	0	0
LINE UTILIZATION	.004	.003	.004	.003	.002	.010	.003	.005	.004	.004
DISTNCE FROM HSC TRAFFIC	399	379	287	731	294	356	356	755	368	368
LINE TO CPU	.980	.584	.837	.747	.341	3.360	1.023	1.543	1.183	.600
CPU TO LINE	2.564	1.411	2.373	1.588	1.088	7.415	1.956	3.707	2.925	1.473
LINE RESPONSE TIME	3.279	3.276	3.278	3.277	3.275	3.296	3.278	3.283	3.281	3.276
SURTOTAL										
INST. COSTS										
LINES	0	0	0	0	0	0	0	0	0	0
SER.T.	20	20	20	20	20	20	20	20	20	20
MODEM	100	100	100	100	100	100	100	100	100	100
DROP	0	0	0	0	0	0	0	0	0	0
ANNUAL RECURR. COST										
LINES	229750	14364	13644	11332	11916	10580	2563	2563	12780	13248
SER.T.	8640	360	360	360	360	360	360	360	360	360
MODEM	12672	528	528	528	528	528	528	528	528	528
DROP	5760	240	240	240	240	240	240	240	240	240
TOTAL COST										
INST. COST	2840	120	120	120	120	120	120	120	120	120
RECUR. COST	256422	15492	14772	11460	13044	11712	3601	3601	13908	14376
REGIONAL STAR NETWORK AND ITS COSTS- 2										
SYSTEM TERMN.	AZTI	AZGL	AZLK	AZLL	AZLR	AZLJ	AZKS	AZLE	AZLF	AZLN
NO. OF LINES RFD.										
1.2KB	1	1	1	1	1	1	1	1	1	1
2.4KB	0	0	0	0	0	0	0	0	0	0
4.8KB	0	0	0	0	0	0	0	0	0	0
LINE UTILIZATION	.003	.016	.004	.012	.005	.004	.003	.008	.002	.004
DISTNCE FROM HSC TRAFFIC	373	332	332	332	316	311	311	334	334	357
LINE TO CPU	.715	4.149	32.308	5.281	1.335	.763	.537	2.279	.537	.088
CPU TO LINE	2.135	13.140	45.424	7.884	3.161	2.295	1.325	5.452	1.115	2.783
LINE RESPONSE TIME	3.278	3.311	3.461	3.301	3.281	3.278	3.275	3.289	3.275	3.280
SURTOTAL										
INST. COSTS										
LINES	0	0	0	0	0	0	0	0	0	0
SER.T.	20	20	20	20	20	20	20	20	20	20
MODEM	100	100	100	100	100	100	100	100	100	100
DROP	0	0	0	0	0	0	0	0	0	0
ANNUAL RECURR. COST										
LINES	13428	2390	2390	2390	11376	2239	2239	12024	12024	12780
SER.T.	360	360	360	360	360	360	360	360	360	360
MODEM	528	528	528	528	528	528	528	528	528	528

Table 3-3. Printer Output from the Example Run
(Continuation 4)

DROP	240	240	240	240	240	240	240	240	240	240
TOTAL COST										
INST. COST	120	120	120	120	120	120	120	120	120	120
RECUR. COST	14556	3514	3514	3514	12504	3367	3367	13152	13152	13836

REGIONAL STAR NETWORK AND ITS COSTS- 3					
SYSTEM TERM.	NAAE	NABG	NACG	NAFA	AAAA
NO. OF LINES REQ.					
1.2KB	1	1	1	1	0
2.4KB	0	0	0	0	0
4.8KB	0	0	0	0	0
LINE UTILIZATION	.002	.002	.002	.002	.000
DISTNCE FROM RSC	399	310	355	361	0
TRAFFIC					
LINE TO CPU	.221	.221	.357	.284	.000
CPU TO LINE	.701	.701	1.131	.648	.000
LINE RESPONSE TIME	3.273	3.273	3.273	3.273	.000
SURTOTAL					
INST. COSTS					
LINES	0	0	0	0	0
SER.T.	20	20	20	20	0
MODEM	100	100	100	100	0
DROP	0	0	0	0	0
ANNUAL RECURR. COST					
LINES	14364	11160	12780	12996	0
SER.T.	360	360	360	360	0
MODEM	528	528	528	528	0
DROP	240	240	240	240	0
TOTAL COST					
INST. COST	120	120	120	120	0
RECUR. COST	15492	12288	13908	14124	0
TOTAL COST=	259702				

Table 3-3. Printer Output from the Example Run
(Continuation 5)

FINAL MULTIDROP NETWORK AND ITS COSTS- 1			
SUBNET NO.	1	2	
BEGINNING NODE	AZLL	AZKS	
NO. OF TERM.	19	6	
NO. OF LINES			
1,2KB	1	1	
2,4KB	0	0	
4,8KB	0	0	
LINE UTILIZATION	.138	.017	
TOTAL MILEAGE	617	388	
TRAFFIC			
LINE TO CPU	55.691	5.305	
CPU TO LINE	100.777	13.617	
LINE RESPONSE TIME	4.038	3.416	
	SUBTOTAL		
INST. COSTS			
LINES	0	0	
SER.T.	260	190	70
MODEM	1300	950	350
DROP	0	0	
ANNUAL RECURR. COST			
LINES	16422	11411	5011
SER.T.	4680	3420	1260
MODEM	6864	5016	1844
DROP	3120	2280	840
TOTAL COST			
INST. COST	1560	1140	420
RECUR. COST	31086	22127	8959
	TOTAL COST=	32646	

Table 3-3. Printer Output from the Example Run
(Continuation 6)

⑭ → REGIONAL CENTRE= AAAA
SUBNETWORK
BEGINS AT

AZLL					
	AZLP				
		AZLA			
			AZXZ		
				NABG	
			AZTI		AZKW
				AZKA	
					NACG
					AZKK
					AZLO
					AZLI
				AZLC	
	AZLK				
		AZGL			
			AZLR		
				AZLG	
AZKS					
	AZLJ				
		AZLF			
			NAFA		
				AZLN	
			AZLE		

individual line type under consideration. For example, a modem turn-around time of 50 milli-seconds has been used in the run.

Item 3 shows the traffic characteristic as calculated by the STACOM program and item 4 prints out the pre-assignment activities. In this example run, the system termination AAAA is preselected as the regional switching center; since only one region is under consideration, all of the remaining system terminations are assigned to region 1.

Item 5 shows a small portion of a traffic matrix from each system termination to four data bases calculated by the program. Item 6 prints the total incoming/outgoing traffic in bps to/from each individual system termination. Also included is total incoming/outgoing traffic to/from the system.

Item 7 gives a short list of point-to-point distances between system terminations as calculated by the program.

Item 8 gives the system centroid as designated from the input. Item 9 shows the CPU utilization at the central switcher of the system being studied.

Item 10 gives the IDs and names of all system terminations in the region and their internal indices. Item 11 prints the regional switching center for the region which has been preselected. In this run, the RSC turns out to be the central switcher.

Item 12 provides the details of the star network developed by the program. For example, the system termination AZLI is linked to the regional switching center AAAA by a 1200 bps line. With the traffic as shown, its line utilization is only .004 and response time 3.279 seconds. It is 399 miles away from AAAA. Based on the tariff applicable for Texas, its installation costs are \$20 for service terminal and \$100 for modems. Annual recurring costs are \$892 for lines, \$360 for service terminals, \$528 for modems and \$240 for the drop charges. After the printout for the star network, the multidrop network (as generated by the STACOM program) is printed as given by item 13. In this example run, two distinctive subnetworks have been generated. Both subnetworks require only the 1200 bps lines. In addition to data similar to item 12, it also includes the total number of terminals on each multidrop line and the total connection mileage. Summarized costs are also provided.

Finally, the actual structure of the final multidrop network is printed as item 14. It is printed in a tree-type form, relating each individual termination to others.

The above described printer output is a copy of the FORTRAN output alternate file, 100. In addition to this, a regular FORTRAN output file, 6, is generated by the program. For this example run, Table 3-4 is the copy of output file, 6. It indicates all of the request messages go by the program during its input phase. The last two lines are an indication that the program has been successfully executed.

Table 3-4. Unit 6 Printer Output from the Example Run

```

ASSUME NUMBER OF REGIONS
ENTER NR AND STRIKE RETURN KEY
TYPE IN NO. OF SYS. TERMNS, DATA BASES AND CITIES WITH FORMAT 315
THERE ARE 25SYS. TERMNS., 4 DATA BASES 358 CITIES
TYPE IN DATA BASE LOCATIONS WITH FORMAT 6(1X,A4)
4 DATA BASES ARE AT AAAA DDDD SSSS HHHH
TYPE IN CITY V-H WITH FORMAT (33X,15,2X,15)
TYPE IN PID NO., NAME, MAPPING ADR. AND TRAFFIC
WITH FORMAT 14,1X,4A6,14,6F8.2
TYPE IN NO. OF RATE STRUCTURES UNDER
CONSIDERATION WITH FORMAT 13
TYPE IN RATE APPLICATION TO EACH COMM.
WRT EACH SYS. TERM. WITH FORMAT 1012
READ IN TRAFFIC DENSITY TYPE AND RATE STRUCTURE
FOR EACH CITY WITH FORMAT 0011
TYPE IN NO. OF LINE TYPES APPLICABLE WITH FORMAT 13
TYPE IN NAME, CAPACITY, UTIL. FACTOR AVAIL. FOR
EACH LINE TYPE WITH FORMAT A6,1X,16,1X,13,2,2(1X,11)
TYPE IN NO. OF DEVICES AND NAMES FOR EACH LINE TYPE
WITH FORMAT 13/10(A6,1X)
TYPE IN INST. AND RECUR. COSTS WRT
RATE STRUCTURE, LINE TYPE, DEVICE, TRAFFIC DENSITY
AND DUPLEXING MODE WITH FORMAT 2F9,2/2F9.2
TYPE IN INST. COSTS ON LINES WRT
RATE, LINE, DENSITY, & DUPLEXING MODE
WITH FORMAT 4F9.2
TYPE IN INDEX FOR LINEARITY OF LINE RECUR. COST
FUNCTION WITH 1=LINEAR AND NONLINEAR OTHERWISE
WITH FORMAT 11 FOR EACH LINE TYPE
TYPE IN RECUR. COSTS WITH FORMAT 4F9.2 IF LINEAR
WITH FORMAT 10F9.3/10F9.3 IF NONLINEAR
IF NONLINEAR, USE 10F8.2
TYPE IN ACTION INDICES FOR EACH REGION
1ST ELEMENT: 1= INSERTION TO THIS PRELOADED REGION IS OK
2ND ELEMENT: 1= OPTIMIZATION IS NEEDED
TYPE IN REGION INDEX AND ACTION NUMBER NEEDED
WITH FORMAT 212 AND END IT WITH A 0 0
TYPE IN NPL, NAK, NPLON, NAKON, MON,
TANOM, TAD IN FORMAT (514,2F7.5)
TYPE IN NO. OF MSG TYPES, AND TRAFFIC STATISTICS
SUCH AS MSGNAM, MSLIN, MSLOUT, RATIO WITH
FORMAT 14/(A6,2(214,2F6.3))
TYPE IN PRELOADED SYSTEM TERMN. AND RSC WITH
FORMAT 11,1X,A4,A5
32A3 DISTANCE ITEMS ARE OVERSIZED
ASSUME A SYSTEM CENTROID
ENTER CODE FOR MSCC AND STRIKE RETURN KEY
INPUT TOTAL NO. OF TRANSACTIONS AND NO. OF ACCESS AT THE SWITCHER
ENTER WITH F8.4 AND 13 UNDER XSAC/SEC
READ IN LIMITS ON NO. OF SYS. TERMS, ON A LINE
RESPONSE TIME REQD AND NO. OF PROCESSORS WITH FORMAT
13,F5,2,12
IF PLOTTING IS REQUIRED, TYPE 1 WITH FORMAT 13
TRYLNK HAS BEEN ACCESSED FOR 10052 TIMES
UPNETW HAS BEEN ACCESSED FOR 22 TIMES

```

QHRKPT PRINTS

3.4.3.2 CalComp Plot. Figure 3-1 is the actual network graph as plotted by the CalComp plotter. It reflects the network as printed in the last part of printer output. It should be noted that because of the existence of identical V-H coordinates associated with system terminations in the example run, fewer distinctive nodes are shown in the plot. The root node is for the system termination, AAAA, which is the location of the Austin central switcher as used in the example run.

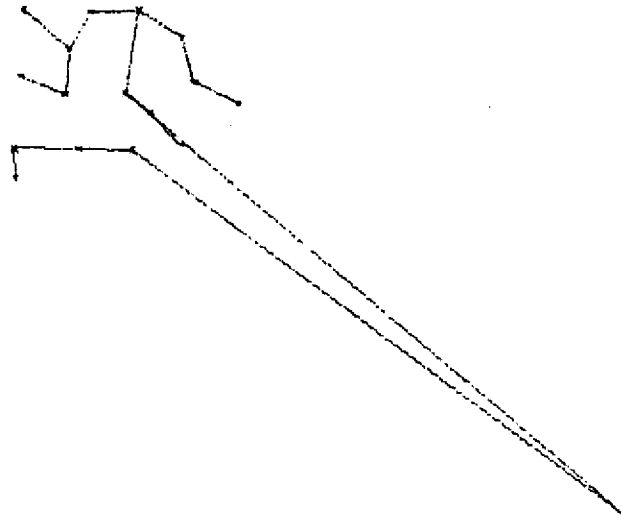


Figure 3-1. CalComp Plot from the Example Run

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2. "FORTRAN V Programmer's Reference", UNIVAC Series, UP-4060, Rev. 2, UNIVAC, A Division of Sperry Rand Corporation, Blue Bell, Pa.
3. Martin, J., System Analysis for Data Transmission, Prentice-Hall, Inc., Englewood Cliffs, New Jersey
4. Karnaugh, M., Multipoint Network Layout Program, Internal Document RC (#16892), IBM Thomas J. Watson Research Center, New York
5. Fielding, J., Frewing, K., and Reilly, N., "Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network", State Criminal Justice Telecommunications (STACOM) Final Report, JPL Document 77-53, Vol. II, Jet Propulsion Laboratory, Pasadena, Calif.

APPENDIX A

STACOM PROGRAM LISTING

51928*STACOM(1),MAIN/0777

```

1 C*****C
2 C*
3 C* STACOM TOPOLOGY PROGRAM *C
4 C* JET PROPULSION LABORATORY *C
5 C* 4800 OAK GROVE DRIVE *C
6 C* PASADENA, CALIFORNIA 91103 *C
7 C*
8 C*****C
9 C
10 C THIS PROGRAM IS DESIGNED TO PERFORM FORMATIONS OF REGIONS, SELECTIONS
11 C OF REGIONAL SWITCHING CENTERS, FORMATIONS OF INITIAL REGIONAL NETWORKS,
12 C OPTIMIZATION OF REGIONAL NETWORKS USING THE FSAU-WILLIAMS METHOD IF
13 C REQUESTED, AND FINALLY FORMATION OF AN INTERREGION NETWORK AND ITS
14 C OPTIMIZATION
15 C
16 C *****
17 C
18 C THIS TOPOLOGY PROGRAM CONTAINS ONE MAIN PROGRAM AND ELEVEN SUBPROGRAMS.
19 C THEY ARE AS FOLLOWS:
20 C MAIN PROGRAM : MAIN (REGION ASSIGNMENTS OF SYSTEM TERMINATIONS)
21 C SUBPROGRAM-1 : RGNNET (REGIONAL NETWORK FORMATION AND ITS OPTIMIZATION)
22 C SUBPROGRAM-2 : IRNOP (INTER-REGION NETWORK OPTIMIZATION)
23 C SUBPROGRAM-3 : ICOSTJ (COSTING FUNCTION)
24 C SUBPROGRAM-4 : RHOFUN (LINE UTILIZATION FUNCTION)
25 C SUBPROGRAM-5 : LINNUM (LINE CONFN. DEFINITION BASED ON TRAFFIC)
26 C SUBPROGRAM-6 : PACK (STORING OR RETRIEVING DISTANCE DATA)
27 C SUBPROGRAM-7 : DIST (FINDING DISTANCE BETWEEN TWO GIVEN TERMINALS)
28 C SUBPROGRAM-8 : LINK (FINDING COMPRESSED INDEX FOR DIST)
29 C SUBPROGRAM-9 : RECOVER (RECOVERING COMPRESSED DISTANCE DATA)
30 C SUBPROGRAM-10: PLOTPT (PLOTING EACH DROP ON A MULTIDROP NETWORK)
31 C SUBPROGRAM-11: RSPNSE (ESTIMATING RESPONSE TIME)
32 C
33 C *****
34 C PARAMETER MW=4,INT=100,NLIMIT=2,NPC=360,NP0=18
35 C PARAMETER NP1=130, NP2=1, NP3=4, NP4=3
36 C PARAMETER NP6=(NPC*NPC/2-NPC+1)/4+1
37 C PARAMETER NP7=4,NP0=10*NPC
38 C COMMON /EIN/ SVR(NP1),NRSC(MW),NUMRR(MW),TRAFFN(NP1),
39 C * TRAFIT(NP1)
40 C * /VH/ IVERT(NPC), IHORZN(NPC)
41 C * /CONST/ N1,N2,N3,N4,N7,NCITY
42 C * /INF/ IRATEJ(NP2,NP2),IRAND(NPC,2),IFLAG(NP2,NP3)
43 C * /BCOST/ AINSTC(NP2,NP3,NP4,3,2,2),RRCRC(NP2,NP3,NP4,3,2,2),
44 C * ANSTLN(NP2,NP3,3,2,2),RECRN(NP2,NP3,3,2,16),INDLX(NP3)
45 C * /LINCR/ LINMIX(NP3),LINCAP(NP3),UTILI7(NP3)
46 C * /REF/ IREF(NPC),TRAFFD(NP1,2,NP7),DISTNCE(NP6),MAPADR(NP1)
47 C * /OVFR/ TVRD(NP0,2),IOVER1
48 C * /NAME/ NAMEST(NP1,4),LNAME(NP3),NAMEHW(NP4)
49 C * /SUM/ ASUM(4),BSUM
50 C * /XMT/ TIMXMT(7,NP3),WAIT(6)
51 C * /MSLA/ AMSL(?)
52 C * /BOUND/ NTERMS,TIMREQ,MPROC,MPL0T
53 C * /ADD/ IADD(NP1),KCHG,KADD QKCHG=FIRST DROP, KADD=JUST FOR LINE
54 C INTEGER DSTNCF
55 C DIMENSION IACTN(MW,2),INDYPT(NP1)
56 C DIMENSION NUMRR(NP1),ITRAFC(2),NBASF(NP7)

```



```

57      DATA ITRAFCL, ITRAFINTREOUT, /
58      DIMENSION TRM(MW,MW), DRM(MW,MW), NUMR(NP1), NUMR(NP1,4)
59      INTEGER SVR
60      DIMENSION OUTPRT(NP1)
61      NMAX=NPO    QMAXIMUM SIZE FOR OVERFLOW DISTANCE DATA TABLE
62      CPIAVG=0.
63      C
64      C SELECT NUMBER OF REGIONS
65      C
66      225 WRITE(6,220)
67      READ(5,735) NR1
68      WRITE(IWT,1011) NR1
69      ANR1=NP1
70      C
71      C READ IN TRAFFIC DENSITY INDEX AND RATE STRUCTURE FOR EACH SYSTEM
72      C TERMINATION IN THE SYSTEM
73      C
74      CALL CREADA(N1)
75      C
76      C READ IN RATE APPLICATION MATRIX
77      C
78      CALL CREADB(N2)
79      C
80      C READ IN NAMES, CAPACITIES, UTILIZATION FACTORS AND AVAILARILITIES
81      C FOR LINES APPLICABLE IN THE SYSTEM
82      C
83      CALL CREADC(N3)
84      C
85      C READ IN INSTALLATION AND RECURRING COSTS FOR CHARGEABLE ITEMS
86      C REQUIRED FOR COMMUNICATION LINES
87      C
88      CALL CREADD(N4)
89      C
90      C READ IN INSTALLATION AND RECURRING COSTS FOR LINES
91      C
92      CALL CREADF
93      C
94      C READ IN ACTIONS TO BE PERFORMED ON EACH REGIONAL NETWORK
95      C 1ST ELEMENT : 1=INSERTIONS TO PRELOADED REGIONS ARE ALLOWED
96      C                0= SUCH AN ACTION IS NOT ALLOWED
97      C 2ND ELEMENT : 1=NETWORK OPTIMIZATION IS TO BE PERFORMED
98      C                0=NO OPTIMIZATION IS NEEDED
99      C
100     CALL CREADK
101     C
102     C READ IN LINE AND LINE PROTOCOL CHARACTERISTICS
103     C
104     CALL CREADR
105     C
106     C CONVERT TRAFFIC FROM CHARACTERS/MIN TO BITS/SEC
107     C
108     DO 85 K=1,2
109     DO 85 I=1,N1
110     DO 85 L=1,N7
111     TRAFD(I,K,L)=TRAFD(I,K,L)*8./60.
112     85 CONTINUE
113     ISUM=0

```

```

114      DO 25 I=1,NCITY
115          ISUM=ISUM+I
116          IREF(I)=ISUM
117      25  CONTINUE
118      DO 701 I=1,NR1
119          NUMPR(I) = 0 QNO. OF SYSTEM TERMINATIONS AT EACH REGION
120      701  CONTINUE
121          WRITE(6,888)
122      805  READ(5,800) NCODE,NSTATE,NRFGO
123          WRITE(IWT,804) NCODE, NSTATE, NREGO
124          NSTATE=LOCAL(NSTATE) QFIND CARDINAL INDEX
125          GO TO(A01,A02,240),NCODE
126      802  CONTINUE
127          SVR(NSTATE) = NREGO
128          NUMPR(NREGO) = NUMPR(NREGO) + 1
129      801  CONTINUE
130          NRSC(NREGO) = NSTATE
131          GO TO 805
132      240  CONTINUE
133          DO 70 L=1,N1
134              TRAFON(L)=0.
135      70  CONTINUE
136          IOVER1=1 QCOUNTER FOR OVERSIZED TRAFFIC DATA
137      C
138      C CALCULATE DISTANCE DATA BETWEEN SYSTEM TERMINATIONS
139      C
140          DO 20 J=1,NCITY
141              DO 30 K=1,NCITY
142                  IF(J=K) 51,30,30
143      51  CONTINUE
144              ISQ1=(IVERT(J)-IVERT(K))**2
145              ISQ1=ISQ1+(IHORZN(J)-IHORZN(K))**2
146              IF(ISQ1.EQ. 0)GOTO 22
147              SQ1=ISQ1/10.
148              NSQ1=INT(SQ1)
149              DIFF=SQ1-NSQ1
150              IF(DIFF.GT. 0.) SQ1=NSQ1+1.
151              BDIST= SQRT(SQ1)
152              KDIST=INT(BDIST)
153              DIFF=BDIST-KDIST
154              IF(DIFF.GT. 0.) KDIST=KDIST+1
155              GOTO 23
156      22  CONTINUE
157              KDIST=0
158      23  CONTINUE
159              JKL=LINK(J,K)
160              IF(KDIST.LE. 510) GOTO 5
161              CALL OVERFL(JKL,KDIST)
162              GOTO 30
163      5  CONTINUE
164              CALL PACK(JKL,KDIST,1,DSTNCF)
165      30  CONTINUE
166      20  CONTINUE
167          IOVER1=IOVER1-1
168          WRITE(6,3) IOVER1
169      C
170      C TOTAL INPUT TRAFFIC BY EACH SYS. TERMN.

```

```

171 C
172 TRFALL=0.0
173 TALLIT=0.
174 TALLDN=0.
175 DO 41 L=1,N1
176 TRAFIT(L)= 0.0
177 TRAFDN(L)= 0.0
178 DO 42 J=1,N7
179 TRAFIT(L) = TRAFIT(L) + TRAFD(L,2,J)
180 TRAFDN(L) = TRAFDN(L) + TRAFD(L,1,J)
181 42 CONTINUE
182 TALLDN=TALLDN+TRAFDN(L)
183 TALLIT=TALLIT+TRAFIT(L)
184 41 CONTINUE
185 TRFALL=TALLDN+TALLIT
186 C
187 C PPINT OUT TRAFFIC DATA BETWEEN SYSTEM TERMINATIONS
188 C
189 NTURN=N1/15 + 1
190 NREM=MOD(N1,15)
191 IF(NREM .EQ. 0) NTURN=NTURN-1
192 WRITE(IWT,111)
193 DO 1100 KK=1,1 FOR TEST ONLY
194 KK1=(KK-1)*15 + 1
195 KK2=KK*15
196 IF(KK2 .GT. N1) KK2=N1
197 WRITE(IWT,113) (INDXPT(J), J=KK1, KK2)
198 DO 99 J=1,N7
199 DO 97 KT=1,2
200 DO 28 KR=KK1, KK2
201 OUTPRT(KR)=TRAFD(KR,KT,J)
202 28 CONTINUE
203 WRITE(IWT,110) ,TRAFD(KT), (OUTPRT(K), K=KK1, KK2)
204 97 CONTINUE
205 99 CONTINUE
206 1100 CONTINUE
207 C
208 C PRINT OUT TRAFFIC ORIGINATED FROM EACH SYSTEM TERMINATION
209 C
210 WRITE(IWT,1013)
211 WRITE(IWT,1001) (INDXPT(NJ), TRAFDN(NJ), NJ=1,N1)
212 WRITE(IWT,74) TALLDN
213 C
214 C PPINT OUT TRAFFIC DESTINATED TO EACH SYSTEM TERMINATION
215 C
216 WRITE(IWT,1014)
217 WRITE(IWT,1001) (INDXPT(NJ), TRAFIT(NJ), NJ=1,N1)
218 WRITE(IWT,74) TALLIT
219 WRITE(IWT,75) TRFALL
220 C
221 C PPINT OUT DISTANCE DATA BETWEEN SYSTEM TERPMINATIONS
222 C
223 NTURN=N1/15+1
224 NREM=MOD(N1,15)
225 IF(NREM.EQ.0) NTURN=NTURN-1
226 NTURN=1 FOR SHORT OUTPUT
227 DO 101 KK=1, NTURN

```

```

228      KK1=(KK-1)*15 + 1
229      KK2=KK*15
230      IF(KK2 .GT. N1) KK2=N1
231      WRITE(IWT,100) (INDXPT(J),J=KK2,KK1,-1)
232      DO 98 J=1,KK2
233          IF(J.GE.KK1) KK1=J+1
234          DO 27 KR=KK2,KK1,-1
235              OUTPRT('R')=DIST(J,KR)
236      27      CONTINUE
237          WRITE(IWT,112) INDXPT(J),(OUTPRT(K),K=KK2,KK1,-1)
238      98      CONTINUE
239      101     CONTINUE
240          WRITE(6,210)
241      4005     CONTINUE
242          READ(5,734) NSCC1
243          WRITE(IWT,1015) NSCC1
244          NSCC1=LOCAL(NSCC1)
245          IF(NSCC1.NE.0) GOTO 4003
246          WRITE(6,4013)
247          GOTO 4005
248      4003     CONTINUE
249          TPR1 = TRFALL
250          WRITE(6,2101)
251          READ(5,2102) XSAC, NREQSW QNREQSW=NO. OF REQUESTS/TRANS AT SWITCHER
252          WRITE(6,2103)
253          READ(5,2104) NTERMS,TIMREQ,MPRAC
254          WRITE(6,2105)
255          READ(5,2104) MPLOT QMPLOT=1 IF PLOT IS NEEDED
256      C
257      C PRE-CALCULATE CPU TURNAROUND TIME
258      C
259          CALL CWAITC
260      C
261      C SUM UP TOTAL TRAFFIC FOR PRELOADED SYSTEM TERMINATIONS IN REGIONS
262      C WHICH DO NOT ALLOW ANY INSERTIONS OF OTHER SYSTEM TERMINATIONS
263      C
264          TPR2=0
265          DO 77 N=1,N1
266              NK=SVR(N)
267              IF(NK .EQ. 0) GOTO 77 QNOT PRELOADED
268              IF(IACTN(NK,1) .EQ. 0) GOTO 77 QINSERTIONS ARE ALLOWED
269              TPR2=TRAFDN(N) + TRAFIT(N) + TPR2
270      77      CONTINUE
271          DO 76 L=1,NR1
272              IF(IACTN(L,1).EQ.0.OR.MUMPR(L).EQ.0) GOTO 76
273              ANR1=ANR1-1.
274      76      CONTINUE
275          TPR1=TPR1-TPR2
276          IF(NR1 .EQ. 1) GOTO 726 QONE REGION CASE
277      C
278      C DETERMINE LOWER LIMIT FOR AVERAGE REGIONAL TRAFFIC
279      C
280          ZETA=.1
281          IF(ANR1.EQ.0.) GOTO 340
282          TPR=TPR1/ANR1
283          GOTO 350
284      340     CONTINUE

```

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

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285      TPR=TPR1
286      350  CONTINUE
287      TPR=TPR*(1.-ZETA)
288      DO 909 NREG=1,NR1
289          TRFS=0.
290          AMAXD=0.
291          II=0
292          IF(NUMPR(NREG).NE.0) GOTO 5000 QNREG IS A PRELOADED REGION
293      C
294      C ASSIGN SYSTEM TERMINATIONS TO A REGION WITHOUT ANY PRELOADING
295      C
296          DO 400 NI=1,N1
297              IF(SVR(NI).NE.0) GOTO 400 QNI IS PRELOADED
298              ADIST=DIST(NSCC1,NI)
299              IF(ADIST.LE.AMAXD) GOTO 400
300              AMAXD=ADIST  QUPDATE LONGEST DIST. FROM NCCC
301              II=NI  QUPDATE FARTHEST SYS. TERMN.
302      400  CONTINUE
303          NS1=II  QTHE FARTHEST SYSTEM TERMINATION
304          TRFS=TRFS + TRAFDN(NS1) + TRAFIT(NS1)
305          SVR(NS1)=NREG
306          NUMPR(NREG)=NUMPR(NREG)+1
307          IF(TRFS.GT.TPRL) GOTO 707
308          GOTO 7021
309      5000  CONTINUE
310          IF(IACN(NREG,1).EQ.1) GOTO 909 QINSERTIONS ARE NOT ALLOWED
311      C
312      C SUM UP TRAFFIC IN THIS REGION
313      C
314          DO 702 I=1,N1
315              IF(SVR(I).NE.NREG) GOTO 702
316              TRFS=TRFS+TRAFDN(I)+TRAFIT(I)
317              ADIST=DIST(NSCC1,I)
318              IF(ADIST.GT.AMAXD) II=I
319      702  CONTINUE
320              IF(TRFS.GT.TPRL) GOTO 707 QENOUGH TRAFFIC IN THIS REGION
321              NS1=II  QTHE FARTHEST SYS. TERMN. IN THE REGION
322              IF(NRSC(NREG).NE.0) NS1=NRSC(NREG)
323      7021  CONTINUE
324              CALL FINDD(NS1,NS2)
325              IF(NS2.EQ.0) GOTO 909
326              SVR(NS2)=NREG
327              NUMPR(NREG)=NUMPR(NREG)+1
328              TRFS=TRFS+TRAFDN(NS2)+TRAFIT(NS2)
329              IF(NREG.EQ.NR1) GOTO 7021
330              IF(TRFS.GT.TPRL) GOTO 707
331              GOTO 7021
332      707  CONTINUE
333              TPR1=TPR1-TRFS  QUPDATE REMAINING TRAFFIC
334              ANR1=ANR1-1.
335              TPR=TPR1/ANR1  QUPDATE AVERAGE TRAFFIC PER REGION
336              TPRL=TPR*(1.-ZETA)  QUPDATE LOWER LIMIT
337      909  CONTINUE
338          GOTO 703
339      726  CONTINUE
340      C
341      C ONE REGION CASE

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342      C
343      DO 727 NN=1,N1
344      SVR(NN) = 1
345 727      CONTINUE
346      NUMPR(1) = N1
347 703      CONTINUE
348      C
349      C SELECT REGIONAL SWITCHING CENTER
350      C
351      DO 500 J=1,NR1
352      WCASE = 1.0E12
353      NMRR = 0
354      DO 505 K=1,N1
355      IF(SVR(K) .NE. J) GO TO 505
356      NMRR = NMRR + 1
357      NUMR(NMRR) = K
358      NUMRR(NMRR)=INDXPT(K)
359      DO 490 I=1,4
360      NUMB(NMRR,I)=NAMEST(K,I)
361 490      CONTINUE
362 505      CONTINUE
363      C
364      C PRINT OUT PID AND NAMES FOR SYSTEM TERMINATIONS IN THE REGION J
365      C
366      WRITE(IWT,1018) J,(NUMRR(I),(NUMB(I,I),I=1,4),I=1,NMRR)
367      C
368      C PRINT OUT INDICES OF SYSTEM TERMINATIONS IN THE REGION J
369      C
370      WRITE(IWT,1028) (NUMR(I),I=1,NMRR)
371      C
372      IF(NRSC(J) .NE. 0) GO TO 501  QPPE-SELECTED
373      DO 520 K=1,NMRR
374      NN1 = NUMR(K)          QASSUMED RSC
375      SUMT = 0.0
376      DO 530 L=1,NMRR
377      NN2 = NUMR(L)
378      SUMT=SUMT+(TRAFON(NN2)+TPAFIT(NN2))*DIST(NN2,NN1)
379 530      CONTINUE
380      IF(SUMT .GT. WCASE) GO TO 520
381      WCASE = SUMT
382      NRSC(J) = NN1
383 520      CONTINUE
384 501      CONTINUE
385      NN4=NRSC(J)
386      WRITE(IWT,1003) INDXPT(NN4),J
387      IGO=IACTN(J,2) QIF 1, OPTIMIZATION IS REQUIRED
388      CALL RGNNET(J,NMRR,NUMR,IGO,NUMRR)
389 500      CONTINUE
390      C
391      C GENERATE INTER-REGION ORIGIN-DESTINATION MATRIX
392      C
393      C INITIALIZATION
394      C
395      IF(NR1.LE.2) GOTO 551
396      DO 902 K1=1,N7
397      KKK=NBASE(K1)
398      KKK=LOCAL(KKK)

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399      IF(KKK.EQ. 0) WRITE(6,7777) K1
400      NBASF(K1)=SVR(KKK)
401  902  CONTINUE
402      DO 699 K1=1,NR1
403      DO 699 K2=1,NR1
404          TRM(K1,K2)=0.
405          TRM(K2,K1)=0.
406  699  CONTINUE
407      DO 900 J=1,NR1
408          NMAR = 0
409          DO 905 K=1,N1
410              IF(SVR(K).NE. J) GO TO 905
411              DO 915 KK=1,N7
412                  NN2=NBASF(KK)  REGIONAL INDEX FOR KK'S DATA BASE
413                  TRM(J,NN2)=TRAFF(K,2,KK)+TRM(J,NN2)  GOING TRAFFIC
414                  TRM(NN2,J)=TRAFF(K,1,KK)+TRM(NN2,J)  INCOMING TRAFFIC
415  915  CONTINUE
416  905  CONTINUE
417      DO 920 J1=1,NR1
418          NN2 = NRSC(J1)
419          DRM(J,J1) = DIST(NN1,NN2)
420  920  CONTINUE
421  900  CONTINUE
422      NTURN=NR1/10+1
423      DO 535 L=1,NTURN
424          LL=(L-1)*10+1
425          LU=L*10
426          IF(LU.GT.NR1) LU=NR1
427          WRITE(IWT,1030) NR1,NR1,(K,K=LL,LU)
428          DO 1022 I=1,NR1
429              WRITE(IWT,1021) I,(TRM(I,J),J=LL,LU)
430  1022 CONTINUE
431  535  CONTINUE
432      DO 545 L=1,NTURN
433          LL=(L-1)*10 + 1
434          LU=L*10
435          IF(LU.GT. NR1) LU=NR1
436          WRITE(IWT,1031) NR1,NR1,(K,K=LL,LU)
437          DO 1024 I=1,NR1
438              WRITE(IWT,1021) I,(DRM(I,J),J=LL,LU)
439  1024 CONTINUE
440  545  CONTINUE
441  C    CALL IRNOP(NR1,NLIMIT,TRM)
442  74   FORMAT(//,40X,' TOTAL TRAFFIC=',F9.2)
443  75   FORMAT(//,35X,' TOTAL SYSTEM TRAFFIC=',F9.2)
444  220  FORMAT('1 ASSUME NUMBER OF REGIONS')
445  *    /* ENTER NR AND STRIKE RETURN KEY */
446  735  FORMAT(I3)
447  888  FORMAT(1X,'TYPE IN PRELOADED SYSTEM TERMN. AND PSC WITH',
448  1    /,1X,'FORMAT I1,1X,A4,A5')
449  800  FORMAT(I1,1X,A4,I5)
450  804  FORMAT(10X,I1,2X,A4,I5)
451  3    FORMAT(1X,I8,' DISTANCE ITEMS ARE OVERSIZED')
452  210  FORMAT(' ASSUME A SYSTEM CENTROID')
453  *    /* ENTER CODE FOR NSCC AND STRIKE RETURN KEY */
454  734  FORMAT(A4)
455  4013 FORMAT(' THE GIVEN SYSTEM COMM. CENTROID IS NOT OK, RETYPE IT')

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456 2101 FORMAT(1X,'INPUT TOTAL NO. OF TRANSACTIONS AND NO. OF ACCESS ',
457 1 'AT THE SWITCHER',/,1X,'ENTER WITH F8.5 AND I3 UNDER XSAC/SEC')
458 2102 FORMAT(F8.5,I3)
459 2103 FORMAT(1X,'READ IN LIMITS ON NO. OF SYS. TERMS. ON A INF',/,
460 1 'RESPONSE TIME REQD AND NO. OF PROCESSORS WITH FORMAT ',
461 2 '/',1X,F5.2,I2')
462 2104 FORMAT(I3,F5.2,I2)
463 2105 FORMAT(1X,'IF PLOTTING IS REQUIRED: TYPE 1 WITH FORMAT (3)')
464 110 FORMAT(//,1X,A6,2X,15F8.1))
465 111 FORMAT(1H1,50X,'TRAFFIC MATRIX(PPS) ')
466 113 FORMAT(//,1X,'TERM. ',4X,15(4X,A4), / )
467 109 FORMAT(1H1,40X,'POINT TO POINT DISTANCE MATRIX ',
468 * //,1X,'TERM. ',15(4X,A4), / )
469 112 FORMAT((2X,A4,15F8.0))
470 1001 FORMAT((1X,5(6X,A4,2X,F10.3),/))
471 1003 FORMAT(//,1X,'RSC=',2X,A4,' FOR REGION',I5)
472 1011 FORMAT(//,10X,' THERE ARE',I5,' REGIONS',/)
473 1013 FORMAT(1H1,35X,' TOTAL TRAFFIC ORIGINATED FROM SYS. TERMN. ',
474 * '(BITS/SEC)',/)
475 1014 FORMAT(//,35X,' TOTAL TRAFFIC DESTINATED TO SYS. TERMN. ',
476 * '(BITS/SEC)',/)
477 1015 FORMAT(//,10X,' NCC= ',2X,A4,/)
478 101A FORMAT(1H1,' REG=',I3,' , SYS. TERMN.=',//,(1X,4(A4,1X,4A6)))
479 7777 FORMAT(1X,'THE',I3,'TH DATA BASE IS NOT GVN AS A SYS. TERM.')
480 1021 FORMAT(//,(15X,I5,5X,10F10.3,/)
481 102A FORMAT(//,' INDICES FOR SYS. TERM.=',//,30I4))
482 1030 FORMAT('1',/,30X,'INITIAL INTERREGION TRAFFIC MATPIX (',
483 * I2,' X',I2,')',/,/,21X,10(5X,I5))
484 1031 FORMAT('1',/,30X,'INTERREGION DISTANCE MATRIX (',I2,' X',I2,')',
485 * 'MILFS',/,/,21X,10(5X,I5))
486 551 CONTINUE
487 STOP
488 SUBROUTINE FINDD(N,M)
489 C *****
490 C
491 C FIND THE NEXT SYSTEM TERMINATION M WHICH IS CLOSEST TO N
492 C WHERE M HAS NOT BEEN ASSIGNED TO ANY REGION YET
493 C
494 C *****
495 AMIN=20000.
496 M=0
497 DO 708 K=1,N1
498 IF(SVR(K).NE.0) GOTO 708
499 ADIST=DIST(N,K)
500 IF(ADIST.GE. AMIN) GOTO 708
501 AMIN= ADIST
502 M=K
503 708 CONTINUE
504 RETURN
505 SUBROUTINE CREADK
506 C *****
507 C READ IN ACTIONS REGARDING INSERTIONS OF SYSTEM TERMINATIONS
508 C TO PRELOADED REGIONS AND REGIONAL NETWORK OPTIMIZATIONS
509 C *****
510 WRITE(6,94)
511 94 FORMAT(' TYPE IN ACTION INDICES FOR EACH REGION ',
512 * '/',1ST ELEMENT: 1= INSERTION TO THIS PRELOADED REGION IS OK ')

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513      * /, 2ND ELEMENT: 1= OPTIMIZATION IS NEEDED)
514      DO 200 NN1=1,NR1
515      DO 200 NN2=1,2
516          IACTN(NN1,NN2)=0
517 200    CONTINUE
518        WRITE(6,206)
519 206    FORMAT(' TYPE IN REGION INDEX AND ACTION NUMBER NEEDED',
520      * /, WITH FORMAT 212 AND END IT WITH A 0 0')
521 250    CONTINUE
522        READ(5,201) NREG, NCODE
523 201    FORMAT(2I2)
524        IF(NREG.EQ. 0) GOTO 265
525        IF(NREG.GT.NR1 .OR. NCODE .GT. 2) GOTO 260
526        IACTN(NREG,NCODE)=1
527        GOTO 250
528 260    CONTINUE
529        WRITE(6,202)
530 202    FORMAT(' PLEASE RETYPE THE INPUT')
531        GOTO 250
532 265    CONTINUE 0NO MORE INPUT
533        RETURN
534        SUBROUTINE CREFADA(N1)
535      C      *****
536      C
537      C FUNCTIONS OF THIS SUBROUTINE ARE TO
538      C 1. RECEIVE TOTAL NO. OF SYSTEM TERMINATIONS, DATA BASES AND CITIES
539      C 2. RECEIVE CITY LOCATIONS (V & H)
540      C 3. RECEIVE PID NO., SYS. TERM. NAMES, ADDR. MAPPING AND TRAFFICS
541      C
542      C      *****
543        WRITE(6,81)
544 81      FORMAT(' TYPE IN NO. OF SYS. TERMNS, DATA BASES AND CITIES '
545      * ' WITH FORMAT 3I5')
546        READ (5,10) N1,N7,NCITY 0 NUMBER OF SYSTEM TERMINATIONS
547        WRITE(6,78) N1,N7,NCITY
548 78      FORMAT(' THERE ARE ',I5,'SYS. TERMNS., ',I4,' DATA BASES,',I5,
549      * ' CITIES',/, ' TYPE IN DATA BASE LOCATIONS WITH FORMAT 6(IY,A4)')
550        READ(5,15) (NBASE(I),I=1,N7)
551 15      FORMAT(6(1X,A4))
552        WRITE(6,16) N7, (NBASE(I),I=1,N7)
553 16      FORMAT(I5,' DATA BASES ARE AT',6(2X,A4))
554        WRITE(6,161)
555 161     FORMAT(' TYPE IN CITY V-H WITH FORMAT (33X,I5,2X,I5)')
556        READ(5,17)(IVERT(I),IHORZN(I),I=1,NCITY)
557 17      FORMAT((33X,I5,2X,I5))
558        WRITE(6,76)
559 76      FORMAT(' TYPE IN PID NO., NAME, MAPPING AND ',
560      * 'AND TRAFFIC',/, ' WITH FORMAT I4,1X,4A6,I4,6F8,2')
561        DO 79 I=1,N1
562        READ(5,80)II,(NAMEST(I,J),J=1,4),(ADD(I),MAPADD(I),((TRAFF(I,K,L),
563      * K=1,2),L=1,N7)
564          INDXPT(I)=II
565 79      CONTINUE
566 80      FORMAT((A4,1X,3A6,A4,I2,I4,4F10,2/4F10,2))
567 10      FORMAT (3I5)
568        RETURN
569        SUBROUTINE CREFADR(N2)

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570 C *****
571 C
572 C CREATE A RATE APPLICATION MATRIX IRATEJ(N2,N2)
573 C
574 C *****
575 WRITE(6,83)
576 83 FORMAT(' TYPE IN NO. OF RATE STRUCTURES UNDER ',
577 * /, ' CONSIDERATION WITH FORMAT I3')
578 READ (5,50) N2
579 WRITE(6,84)
580 84 FORMAT(' TYPE IN RATE APPLICATION TO EACH COMM. ',
581 * /, ' WRT EACH SYS. TERM. WITH FORMAT I0I2')
582 DO 11 IRATE=1,N2
583 READ (5,100) (IRATEJ (J,IRATE),J=1,N2)
584 11 CONTINUE
585 WRITE(6,71)
586 71 FORMAT(' READ IN TRAFFIC DENSITY TYPE AND RATE STRUCTURE ',
587 * /, ' FOR EACH CITY WITH FORMAT 80I1')
588 READ(5,72) ((IRAND(I,J),J=1,2),I=1,NCITY)
589 72 FORMAT(80I1)
590 50 FORMAT (I3)
591 100 FORMAT (I0I2)
592 RETURN
593 SUBROUTINE CREADC(N3)
594 C *****
595 C
596 C READ IN NAMES, UTILIZATION FACTORS AND CAPACITY FIGURES
597 C FOR LINES TO BE USED IN THE SYSTEM
598 C
599 C *****
600 WRITE(6,85)
601 85 FORMAT(' TYPE IN NO. OF LINE TYPES APPLICABLE WITH FORMAT I3')
602 READ (5,50) N3
603 WRITE(6,86)
604 86 FORMAT(' TYPE IN NAME, CAPACITY, UTIL. FACTOR AVAIL. FOR ',
605 * /, ' EACH LINE TYPE WITH FORMAT A6,1X,I6,1X,F3.2,2(IX,I1)')
606 DO 12 I=1,N3
607 READ(5,100)LINAME(I),LINCAP(I),UTILIZ(I),LIMMIX(I),IDUPLY(I)
608 12 CONTINUE
609 50 FORMAT (I3)
610 100 FORMAT(A6,1X,I6,1X,F3.2,2(IX,I1))
611 RETURN
612 SUBROUTINE CREADD (N4)
613 C *****
614 C
615 C CREATE A MATRIX OF BASIC INSTALLATION AND RECURRING COSTS
616 C FOR CHARGEABLE ITEMS, ASSUMING COST IS A LINEAR FUNCTION
617 C
618 C *****
619 WRITE(6,87)
620 87 FORMAT(' TYPE IN NO. OF DEVICES AND NAMES FOR EACH LINE TYPE ',
621 * /, ' WITH FORMAT I3/I0(A6,1X)')
622 READ (5,50) N4, (NAMEHW(I),I=1,N4)
623 WRITE(6,88)
624 88 FORMAT(' TYPE IN INST. AND RECURR. COSTS WRT ',
625 * /, ' RATE STRUCTURE, LINE TYPE, DEVICE, TRAFFIC DENSITY ',
626 * /, ' AND DUPLEXING MODE WITH FORMAT 2F9.2/2F9.2')

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627      DO 13 IRATE=1,N2
628      DO 13 ILINE=1,N3
629      DO 13 IDVICE=1,N4
630      DO 13 IDNSTY=1,3
631      READ(5,100)((AINSTC(IRATE,ILINE,IDVICE,IDNSTY,J,K),K=1,2),J=1,2)
632      READ(5,100)((RECP(C(IRATE,ILINE,IDVICE,IDNSTY,J,K),K=1,2),J=1,2)
633      13      CONTINUE
634      100      FORMAT(2F9.2/2F9.2)
635      50      FORMAT(I3/,10(A6,1X))
636      RETURN
637      SUBROUTINE CREAD
638      C          *****
639      C
640      C CREATE A MATRIX OF BASIC INSTALLATION AND RECURRING COSTS FOR
641      C LINES. COST MAY OR MAYNOT BE A LINEAR FUNCTION OF DISTANCE
642      C
643      C          *****
644      WRITE(6,89)
645      89      FORMAT(' TYPE IN INST. COSTS FOR LINES WRT ',
646      1 /' RATE, LINE, DENSITY, AND DUPLEXING MODE ',
647      2 /' WITH FORMAT 4F9.2')
648      WRITE(6,90)
649      90      FORMAT(' TYPE IN INDEX FOR LINEARITY OF LINE RECUR. COST',
650      1 /' FUNCTION WITH 1=LINEAR AND NONLINEAR OTHERWISE',
651      2 /' WITH FORMAT I1 FOR EACH LINE TYPE')
652      WRITE(6,91)
653      91      FORMAT(' TYPE IN RECUR. COSTS WITH FORMAT 4F9.2 IF LINEAR ',
654      1 /' WITH FORMAT 10F8.3/10F8.3 IF NONLINEAR',
655      2 /' IF NONLINEAR, USE 10F8.2')
656      DO 14 IRATE=1,N2
657      DO 14 ILINE=1,N3
658      READ(5,200) INDEX
659      IFLAG(IRATE,ILINE)=INDEX @LINE COST LINEARITY INDICATOR
660      DO 14 IDNSTY=1,3
661      READ(5,100)((AINSTN(IRATE,ILINE,IDNSTY,I,J),J=1,2),I=1,2)
662      IF (INDEX.NE.1) GO TO 3
663      C      LINEAR COST FUNCTION
664      READ(5,100)((RECLN(IRATE,ILINE,IDNSTY,I,J),J=1,2),I=1,2)
665      GO TO 14
666      3      CONTINUE @ NONLINEAR COST FUNCTION
667      READ(5,401)((RECLN(IRATE,ILINE,IDNSTY,I,J),J=1,16),I=1,2)
668      14      CONTINUE
669      100      FORMAT(14F9.2)
670      200      FORMAT(I1)
671      401      FORMAT((10F8.3/10F8.3))
672      RETURN
673      FUNCTION LOCAL(NL)
674      C          *****
675      C
676      C FIND LOCAL INDEX FOR SYSTEM TERMINATION WITH ID NL
677      C
678      C          *****
679      LOCAL=0
680      IF(NL.EQ.0) RETURN
681      DO 4001 NN=1,N1
682      IF(INDXPT(NN).EQ.NL) GOTO 4002
683      4001 CONTINUE

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684      RETURN
685 4002 LOCAL=NN
686      RETURN
687      SUBROUTINE OVERFL(J,K)
688      C
689      C *****
690      C STORE OVERFLOW ELEMENT (J,K) AT LOCATION IOVER OF TABLE
691      C LA AND PUT A MARK 511 AT LOCATION J OF TABLE MA (DISTNCE)
692      C
693      C *****
694      IF(IOVER1 .GE. NMAX) GOTO P000
695      CALL PACK (J,511,1,DSTNCE)
696      IVRD(IOVER1,1)=J
697      IVRD(IOVER1,2)=K
698      IOVER1=IOVER1+1
699      RETURN
700 8000 CONTINUE
701      WRITE(6,8001)
702 8001 FORMAT(2X,' THE OVERFLOW TABLE HAS BEEN FULLY LOADED.',
703      * /,2X,' PLEASE INCREASE ITS SIZE')
704      STOP
705      SUBROUTINE CREADR
706      C
707      C *****
708      C RECEIVE DATA FOR RESPONSE TIME CALCULATION
709      C
710      C MSLIN(NP9,2)= INPUT MSG LENGTH AS A FUNCTION OF TYPE AND PRIORITY
711      C MSLOUT(NP9,2)=OUTPUT MSG LENGTH AS A FUNCTION OF TYPE AND PRIORITY
712      C AMSL(7)= AVERAGE MSG LENGTH FOR
713      C 1=POLLING 2=NAK RESPONSE 3=INPUT MSG WITH PRIORITY 1
714      C 4=INPUT MSGS 5=OUTPUT MSG WITH PRIO 1
715      C 6=OUTPUT MSGS WITH PRIO 2 7=ALL MSGS
716      C TIMXMT(7,NP3)=AVERAGE TRANSMISSION TIME FOR ABOVE ITEMS
717      C RATPRI(NP9,2,2)=OUTPUT MSG DISTRBUTN AND OUT-GOING MSG RATIO BY PRIO
718      C N,1,1 = PERCENT OF OUTPUT MSG SENT'D WITH PRIO 1 IF ITS TYPE IS N
719      C N,1,2 = PERCENT OF OUTPUT MSG WHOSE DESTINATION IS OUTSIDE OF
720      C RATIO(NP9,2)=INPUT TRAFFIC DISTRI. AS A FUNCTION OF TYPE AND PRIORITY
721      C RATIO(NP9,2) =OUTPUT TRAFFIC DISTRI. AS A FUNCTION OF TYPE AND PRIORITY
722      C
723      C *****
724      DIMENSION MSLIN(NP9,2),RATIO(NP9,2),RATIO1(NP9,2),
725      1 MSLOUT(NP9,2),MSGNAM(NP9),
726      2 NPL(NP3),NAK(NP3),NPLOH(NP3),NAKOH(NP3),
727      3 MOH(NP3),TAMD(NP3),TAPD(NP3)
728      WRITE(6,771)
729 771 FORMAT(' TYPE IN NPL, NAK, NPLOH, NAKOH, MOH,',
730      * /, ' TAMD, TAD IN FORMAT (5I4,2F7.5)')
731      READ(5,77) (NPL(I),NAK(I),NPLOH(I),NAKOH(I),
732      * MOH(I),TAMD(I),TAPD(I),I=1,N3)
733      WRITE(IWT,73) (LINCAP(I),NPL(I),NAK(I),NPLOH(I),NAKOH(I),
734      * MOH(I),TAMD(I),TAPD(I),I=1,N3)
735 73 FORMAT(2X,15,3X,' POLL CHAR.=',I4,' NAK CHAR.=',I4,' POLL O/H=',
736      1 I4,' /,10X,' NAK O/H=',I4,' MSG O/H=',I4,
737      2 /,10X,' MPSEM=',F8.3,' PPSEM=',F8.3))
738 77 FORMAT(5I4,2F7.5)
739      WRITE(6,772)
740 772 FORMAT(' TYPE IN NO. OF MSG TYPES, AND TRAFFIC STATISTICS',

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741      1 //, SUCH AS MSGNAM, MSLIN, MSLOUT, RATIO WITH:
742      2 //, FORMAT (4/(A6,2(2I4,2F6.3)))
743      READ(5,77) NTP
744      READ(5,179) (MSGNAM(I), (MSLIN(I,J), MSLOUT(I,J),
745      * RATIO(I,I,J), RATIO(I,J), J=1,2), I=1, NTP)
746      179 FORMAT((A6,2(2I4,2F6.3)))
747      READ(5,81) CPUAVG
748      81 FORMAT(F7.4)
749      C
750      C CALCULATE AVERAGE MSG LENGTH
751      C
752      DO 61 I=3,7
753      AMSL(I)=0.
754      61 CONTINUE
755      DO 58 I=1,4
756      ASUM(I)=0.
757      58 CONTINUE
758      DO 62 I=1, NTP
759      DO 66 J=1,2
760      J1=J+2
761      J2=J+4
762      AMSL(J1)=AMSL(J1)+MSLIN(I,J)*RATIO(I,J)
763      AMSL(J2)=AMSL(J2)+MSLOUT(I,J)*RATIO(I,J)
764      ASUM(J)=ASUM(J)+RATIO(I,J)
765      ASUM(J1)=ASUM(J1)+RATIO(I,J)
766      66 CONTINUE
767      62 CONTINUE
768      BSUM=0.
769      DO 67 I=1,4
770      J1=I+2
771      AMSL(7)=AMSL(7)+AMSL(J1)
772      BSUM=BSUM+ASUM(I)
773      67 CONTINUE
774      AMSL(7)=AMSL(7)/BSUM OVERALL AVG. MSG LENGTH
775      IF(ASUM(4) .EQ. 0.) GOTO 68
776      AMSL(6)=AMSL(6)/ASUM(4)
777      68 CONTINUE
778      AMSL(5)=AMSL(5)/ASUM(3) QAVG. MSG LENGTH FOR PRIO=1
779      AMSL(4)=(AMSL(3)+AMSL(4))/(ASUM(1)+ASUM(2)) QAVG INPUT MSG LEN.
780      AMSL(3)=AMSL(3)/ASUM(1)
781      WRITE(IWT,105) (AMSL(I), I=3,7)
782      105 FORMAT(/,5X, 'AVG. INPUT MSG WITH PRIO 1=', F6.1, ' CHARS',
783      1 /,5X, 'AVG. INPUT MSG ', F6.1, ' CHARS',
784      2 /,5X, 'AVG. OUTPUT MSG W/H PRIO 1=', F6.1, ' CHARS',
785      3 /,5X, 'AVG. OUTPUT MSG WITH PRIO2=', F6.1, ' CHARS',
786      4 /,5X, ' OVERALL AVG. MSG ', F6.1, ' CHARS')
787      DO 65 K=1, N3
788      AMSL(1)=NPL(K)
789      AMSL(2)=NAK(K)
790      TIMXMT(1,K)=(AMSL(1)+NPL(K))*A./LINCAP(K)+TAMDM(K)
791      TIMXMT(2,K)=(AMSL(2)+NAK(K))*A./LINCAP(K)+TAPD(K)
792      DO 63 J=3,7
793      TIMXMT(J,K)=(AMSL(J)+MOH(K))*A./LINCAP(K)+TAMDM(K)
794      63 CONTINUE
795      65 CONTINUE
796      BSUM=ASUM(3)+ASUM(4)
797      RETURN

```

```

798          SUBROUTINE WAITC
799          C          *****
800          C
801          C PPF-CALCULATE CPU WAIT TIME
802          C
803          C          *****
804          RHOCPU=XSAC*CPUAVG/MPROC
805          WRITE(100,850) RHOCPU
806          850  FORMAT(' CPU UTILIZATION PER PROCESSOR IS ', F5.3)
807          IF(RHOCPU .LE. .8) GOTO 851
808          WRITE(6,855)
809          855  FORMAT(' THE CPU IS OVERLOADED, THEREFORE IT IS NO USE TO ',
810          * 'GO FURTHER.')
811          STOP
812          851  CONTINUE
813          BETA=RHOCPU
814          IF( MPROC .EQ. 1) GOTO 700
815          RH02=RHOCPU**2
816          BETA=2.*RH02/(1+RHOCPU)
817          IF( MPROC .EQ. 2) GOTO 700
818          RH04=RHOCPU**4
819          BETA=256*RH04/(24+72*RHOCPU+96*RH02
820          * +64*RH02*RHOCPU-240*RH04)
821          700  CONTINUE
822          WAIT(4)=CPUAVG*(BETA/(MPROC*(1.-RHOCPU))+1)
823          WAIT(4)=WAIT(4)*NREQSW
824          RETURN
825          END

```

QPRT STACOM.RGNNET/0777

51928*STACOM(1).RGNNET/0777

```

1      SUBROUTINE RGNNET(JREGN, NOREGN, NUMP, IGO, NUMRR)
2      C
3      C *****
4      C DEVELOP A REGIONAL MULTIDROP NETWORK, STARTING WITH A STAR
5      C NETWORK AND THEN OPTIMIZE IT BY ESAU-WILLIAMS METHOD, GIVEN
6      C THE FOLLOWING AUGUMENTS:
7      C
8      C JREGN= THE INDEX FOR THE REGION UNDER CONSIDERATION
9      C NOREGN= THE NUMBER OF SYSTEM TERMINATIONS IN REGION JREGN
10     C NUMP= AN ARRAY THAT CONTAINS INDICES FOR ALL SYSTEM
11     C       TERMINATIONS IN REGION JREGN
12     C IGO= 1 IF NETWORK OPTIMIZATION IS TO BE PERFORMED
13     C
14     C NOTE: NODE AND SYSTEM TERMINATION ARE EXCHANGEABLE
15     C
16     C *****
17     C PARAMETER NP1=130, NP2=1, NP3=4, NP4=3
18     C PARAMETER NP7=4
19     C PARAMETER IWT=100, MW=4, NPC=360
20     C PARAMETER NP6=(NPC*NPC/2-NPC+1)/4+1
21     C COMMON/CONST/ N1,N2,N3,N4,N7,NCITY
22     C * /PEF/ IREF(NPC), TRAFD(NP1,2,NP7), DSTNCF(NP6), MAPADR(NP1)
23     C * /LINCHR/ LINMIX(NP3), LINCAP(NP3), UTILI7(NP3)
24     C * /INF/ IRATEJ(NP2,NP2), IRAND(NPC,2), IFLAG(NP2,NP3)
25     C * /EIN/ SVR(NP1), NRSC(MW), NUMPP(MW), TRAFON(NP1), TRAFIT(NP1)
26     C * /NAME/ NAMEST(NP1,4), LNAME(NP3), NAMEFW(NP4)
27     C * /SUM/ ASUM(4), RSUM
28     C * /MSLA/ AMSL(7)
29     C * /ROUND/ NTERMS, TIMPEQ, MPROC, MPLAT
30     C * /ADD/ IADD(NP1), KCHG, KADD
31     C * /RESP/ RHOLIN(4), RSPTIM
32     C DIMENSION COSTW(NP1,4), IAPRAY(NP1,5), ARRAY(NP1,2)
33     C DIMENSION TIMRSP(NP1), TRFSUM(NP1,2), TIMOUT(NP1)
34     C DIMENSION NLINES(NP1,NP3), LDUMMY(NP3), NUMR(1)
35     C DIMENSION IDST(NP1), LNKCHW(NP3,NP4,2), LNKCLN(NP3,2)
36     C DIMENSION ICSTHW(NP1,NP4,2), ICSTLN(NP1,2), JTCOST(NP1,2)
37     C DIMENSION LSUR(NP1), MSUB(NP1), NSUR(NP1)
38     C DIMENSION IBLANK(NP1), JCHAR(2)
39     C DIMENSION NUMRR(1)
40     C DIMENSION RHOF(NP1)
41     C EQUIVALENCE (JCHAR, ICHAR)
42     C DATA JBLANK/, //
43     C RSPTIM=0.
44     C IPOINT=0
45     C INTEGER TCOST1, TCOST2, COST, COSTFW
46     C
47     C INITIALIZE COST ARRAY, INDEPENDENT OF LINE TYPE
48     C
49     C DO 399 K1=1,N1
50     C DO 399 K3=1,2
51     C   ICSTLN(K1,K3)=0
52     C DO 399 K4=1,N4
53     C   ICSTHW(K1,K4,K3)=0
54     C 399 CONTINUE
55     C NN1=NRSC(JREGN) GLOBAL INDEX FOR RSC
56     C

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57 C FIND THE LOCAL RSC INDEX IN THE REGION ARRAY
58 C
59 DO 9A IND=1,NOREGN
60 IF(IND1.EQ. NUMR(IND)) GOTO 189
61 9A CONTINUE
62 189 CONTINUE
63 IRSC=IND
64 C
65 C BUILD A STAR NETWORK
66 C
67 CALL STAREW
68 C
69 C PRINT OUT STAR NETWORK
70 C
71 CALL SUMPRT(NOREGN,1)
72 IF(IGO.EQ. 0) GOTO 979
73 C
74 C DEVELOP A MULTIDROP NETWORK UTILIZING THE
75 C ESAU-WILLIAMS ALGORITHM
76 C
77 MAXSAV=0
78 MAXM=0
79 MAXL=0
80 MAXK=0
81 MAXKI=0
82 MAXLIN=0
83 MAXNOL=0
84 LINNEW=0
85 RSPMAX=0.
86 RHOMAX=0.
87 ICHAR=' '
88 ITALLY=0
89 JTALLY=0
90 KCHG=1
91 KADD=1
92 IOK=0
93 INTRY=0
94 CALL ESSWIL
95 WRITE(6,933) ITALLY,JTALLY
96 933 FORMAT(2X,'TRYLNK HAS BEEN ACCESSED FOR ',I9,' TIMES',
97 1 /,2X,'UPNETW HAS BEEN ACCESSED FOR ',I9,' TIMES')
98 979 CONTINUE
99 RETURN
100 SUBROUTINE STAREW
101 C *****
102 C
103 C FORM THE INITIAL REGIONAL STAR NETWORK, IARRAY, AND FIND ITS
104 C COST, COSTEW
105 C NOREGN=NUMBER OF SYSTEM TERMINATIONS IN THE REGION
106 C
107 C *****
108 INTEGER COST
109 DO 100 K3=1, NOREGN
110 DO 110 K4=2,4
111 IARRAY(K3,K4)=0
112 110 CONTINUE
113 KK=NUMR(K3)

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```

114      IARRAY(K3,1)=IADD(KK)
115      IARRAY(K3,5)=IRSC  @ LOCAL INDEX FOR RSC
116      ARRAY(K3,1)=TRAFDN(KK)
117      ARRAY(K3,2)=TRAFIT(KK)
118      TIMRSP(K3)=0.
119
100  CONTINUE
120      IARRAY(IRSC,1)=NOREGN - 1  @NO. OF NODES UNDER RSC
121      NM=1  @ASSUMING THE 1ST SUCCESSOR WITH INDEX 1
122      IF(IRSC .EQ. 1) NM=2  @1ST SUCCESSOR IS WITH INDEX 2
123      IARRAY(IRSC,2)=NM
124      IARRAY(IRSC,5)=0
125
C
126  C RFLATE ALL OF RSC'S SUCCESSORS
127  C
128      DO 200 K5=1, NOREGN
129      IF(K5 .EQ. IRSC) GOTO 200
130      NM=NM + 1
131      IF(NM .EQ. IRSC) NM=NM + 1
132      IF(NM .GT. NOREGN) GOTO 200  @END OF SUCCESSORS' LINK
133      IARRAY(K5,3)=NM
134      IARRAY(NM,4)=K5
200  CONTINUE
135
C
136
137  C DETERMINE LINE TYPE FOR CENTRAL LINKS TO RSC
138  C
139      DO 550 NODE=1, NOREGN
140      IF(NODE .EQ. IRSC) GOTO 555
141      TRFIN=ARRAY(NODE,1)+0.5
142      TRFOUT=ARRAY(NODE,2)+.5
143      NN2=NUMR(NODE)
144      DSTN=DIS(NN1,NN2)
145      IDST(NODE)=DSTN
146      COSTW(NODE,4)=DSTN
147
C
148  C TAKE A FIRST GUESS FOR LINE CONFIGURATION
149  C
150      COST=0
151      RHO=0.
152      MDROP=IARRAY(NODE,1)+1
153      CALL LINNUM(TRFIN,TRFOUT,LDUMMY,LINOLD,0,RHO)
154
781  CONTINUE
155
C
156  C COMPUTE INITIAL RESPONSE TIME
157  C
158      IKONT=0
159      DO 783 I=1,N3
160      IF(LDUMMY(I) .NE. 0) IKONT=IKONT+1
161
783  CONTINUE
162      AINTRF=TRFIN
163      OUTTRF=TRFOUT
164      IF(IKONT .EQ. 1 .AND. LDUMMY(LINOLD) .EQ. 1) GOTO 772
165
C
166  C RESPONSE TIME CALCULATION NEEDS MODIFICATION
167  C
168      ACAP=0.
169      DO 771 NL=1,N3
170      ACAP=ACAP+LINCAP(NL)*LDUMMY(NL)

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171          LDUMMY(NL)=0
172      771      CONTINUE
173          LDUMMY(LINOLD)=1
174          AINTRF=TRFIN*LINCAP(LINOLD)/ACAP *PERCENT TRAFFIC
175          OUTTRF=TRFOUT*LINCAP(LINOLD)/ACAP
176      772      CONTINUE
177          CALL RSPNSE(AINTRF,OUTTRF,LINOLD,NOROP,IOK)
178          IF(IOK.EQ. 1) GOTO 773
179          IF(LINOLD.EQ. N3) GOTO 774
180          LDUMMY(LINOLD)=0
181          LINOLD=LINOLD+1
182          LDUMMY(LINOLD)=1
183          GOTO 775
184      774      CONTINUE
185          NLL=0
186          N3=N3-1
187          DO 776 I=1,N3
188              IF(LDUMMY(I).EQ.0) GOTO 776
189              NLL=I
190              GOTO 780
191      776      CONTINUE
192          LDUMMY(1)=1
193          GOTO 775
194      780      CONTINUE
195          LDUMMY(NLL)=0
196          LDUMMY(NLL+1)=LDUMMY(NLL+1)+1
197      775      CONTINUE
198          CALL RHOFUN(TRFIN,TRFOUT,LDUMMY,LINOLD,RHOF,RHO)
199          GOTO 781
200      773      CONTINUE
201          TIMRSP(NODE)=RSPTIM
202          KCHG=2
203          CALL ISUMUP(IRSC,NODE,0,COST)
204          RHOF(NODE)=RHO
205          COSTEW(NODE,1)= COST
206          COSTEW(NODE,2)=LINOLD
207          DO 499 NL=1,N3
208              NLINES(NODE,NL)=LDUMMY(NL)
209          DO 499 NM=1,2
210              ICSTLN(NODE,NM)=ICSTLN(NODE,NM)+LNKCLN(NL,NM)
211          DO 499 NK=1,N4
212              ICSTHW(NODE,NK,NM)=LNKCHW(NL,NK,NM)+ICSTHW(NODE,NK,NM)
213      499      CONTINUE
214          JTRAF=TRFIN+TRFOUT
215          JTRAF=JTRAF/UTILIZ(LINOLD)
216          COSTEW(NODE,3)=JTRAF/LINCAP(LINOLD)+1
217          GOTO 550
218      555      CONTINUE
219      C
220      C ASSUMING TRAFFIC AT IRSC IS TAKEN CARE OF AUTOMATICALLY
221      C
222          DO 498 NL=1,N3
223              NLINES(NODE,NL)=0
224      498      CONTINUE
225          COSTEW(NODE,1)=0
226          COSTEW(NODE,2)=0
227          COSTEW(NODE,3)=0

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228      COSTFW(NODE,4)=0
229      RHOE(NODE)=0.
230 550  CONTINUE
231      RETURN
232      SUBROUTINE ISUMUP(L1,L2,LT,IC)
233  C      *****
234  C
235  C CALCULATE COST BETWEEN NODES L1 AND L2 AND ADD IT TO
236  C TOTAL COST IC WHERE LT=LINE TYPE
237  C
238  C      *****
239      LL1=NUMR(L1)
240      LL2=NUMR(L2)
241      CALL ICOSTJ(LDUMMY,LL1,LL2,LNKCHW,LNKCLN)
242      KK=N3
243      IF(LT.NE.0) KK=1
244      DO 211 LINTYP=1, KK
245          LTYP=LINTYP
246          IF(KK.EQ.1) LTYP=LT
247          DO 221 I1=1,2
248              IC=IC+LNKCLN(LTYP,I1)
249              DO 222 I2=1,N4
250                  IC=IC+LNKCHW(LTYP,I2,I1)
251 222  CONTINUE
252 221  CONTINUE
253 211  CONTINUE
254      RETURN
255      SUBROUTINE ESSWL
256  C      *****
257  C
258  C TRY AGAIN TO OPTIMIZE THE NETWORK
259  C
260  C      *****
261 5000 CONTINUE
262      K=IARRAY(IRSC,2)  @FIRST SUBNETWORK UNDER RSC
263      KNEXT=IARRAY(K,3) @NEXT SUBNETWORK UNDER RSC
264      IF(KNEXT.EQ.0) GOTO 599 @ONLY ONE SUBNETWORK
265 560  CONTINUE
266      IOK=0
267      L=IARRAY(IRSC,2) @K-SUBNET IS TO BE LINKED TO L-SUBNET
268 570  CONTINUE
269      IF(L.NE.K) GOTO 575
270      L=IARRAY(L,3)
271      IF(L.EQ.0) GOTO 660
272 575  CONTINUE
273      K1=NUMR(K)
274      DREF=DIST(NN1,K1)
275  C
276  C TEST TOTAL NO. OF TERMINALS IF K AND L ARE COMBINED
277  C
278      INTRY=0  @INDICATION OF ENTRY TO TRYLNK
279      LINE=COSTFW(K,2)
280      IF(LINCAP(LINE).EQ.9600) GO TO 585 @NO MULTIDROPPING ON 9600
281      NODET=IARRAY(K,1)+IARRAY(L,1)+2
282      IF(NODET.GT.NTERMS) GOTO 585 @TOO MANY TERMINALS
283      M=L
284      KI=K

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285      580  CONTINUE
286          M1=NIMR(M)
287          DTRY=DIST(K1,M1)/2.
288          IF(DTRY .GT. DREF) GOTO 140
289          CALL TRYLNK(K,KI,L,M) @ M IS THE INSEPTION NODE
290          IF(IOK .EQ. 0) GOTO 585
291      140  CONTINUE
292          M=NXTNOD(L,M) @NEXT NODE UNDER M ON L-SUBNET
293          IF(M .NE. 0) GOTO 580 @NO MORE NODES UNDER M ON L-SUBNET
294          KI=NXTNOD(K,KI) @START WITH NEXT NODE ON K-SUBNET
295          IF(KI .EQ. 0) GOTO 585
296          KI=NIMR(KI)
297          M=L
298          GOTO 580
299      585  CONTINUE
300          L=IARRAY(L,3) @NEXT SUCCESSOR
301          IF(L .NE. 0) GOTO 570
302      660  CONTINUE
303          K=IARRAY(K,3)
304          IF(K .NE. 0) GOTO 560 @NOT AN END YET, REPEAT THE SEARCH
305      C
306      C ALL POSSIBLE COMBINATIONS HAVE BEEN TRIED
307      C
308          IF(MAXSAV .LE. 0) GOTO 599 @NO NEED TO GO FURTHER
309      C
310      C UPDATE NETWORK BASED ON UP-TO-DATE MAXIMUM COST SAVING
311      C PARAMETERS
312      C
313          JTALLY=JTALLY+1
314          CALL UPNETW
315      C
316      C REINITIALIZATION
317      C
318          RSPMAX=0.
319          MAXSAV=0
320          MAXK=0
321          MAXL=0
322          MAXM=0
323          MAXKI=0
324          MAXLIN=0
325          LINNEW=0
326          MAXNOL=0
327          RHOMAX=0.
328          GOTO 5000
329      599  CONTINUE
330      C
331      C PRINT OUT COSTS FOR THE OPTIMIZED MULTIDROP NETWORK
332      C
333          CALL MUTDRP
334      C
335      C PRINT OUT THE OPTIMIZED MULTIDROP NETWORK
336      C
337          CALL NETPRT
338          IF(MPLOT .NE. 1) GOTO 50
339          CALL CALPLT
340      50  CONTINUE
341          RETURN

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342      SUBROUTINE TRYLNK(KL,KIL,LL,ML)
343      C
344      C *****
345      C TRY TO ELIMINATE CENTRAL LINK KL AND LINK IT TO THE SUBNETWORK
346      C LL THROUGH SYSTEM TERMINATIONS KIL AND ML.
347      C
348      C *****
349      INTEGER COSTKM,COST
350      ITALLY=ITALLY+1
351      IF(INTRY .EQ. 1) GOTO 719
352      TRFIN=ARRAY(KL,1)+ARRAY(LL,1)+0.5
353      TRFOUT=ARRAY(KL,2)+ARRAY(LL,2)+0.5
354      C
355      C FIND THE LINE WITH THE ENOUGH CAPACITY TO HANDLE
356      C THE TOTAL TRAFFIC ON THE PROPOSED SUBNETWORK LL
357      C
358      CALL LINNUM(TRFIN,TRFOUT,LDUMMY,LINNEW,1,RHO)
359      IF(LINCAP(LINNEW) .EQ. 9600) GOTO 132
360      LINUP=LINNEW-1
361      IF(LINUP .EQ. 0) GOTO 712
362      DO 711 NL=1,LINUP
363          IF(LDUMMY(NL) .EQ. 0) GOTO 711
364          GOTO 132
365      711 CONTINUE
366      712 CONTINUE
367      NLNEW=LDUMMY(LINNEW)
368      IF(NLNEW .GT. 1) GOTO 132 MORE THAN 1 LINE NOT ALLOWED
369      COST=COSTEW(LL,1)
370      LINOLD=COSTEW(LL,2)
371      NLOLD=COSTEW(LL,3)
372      MCOSTL=COST
373      3000 CONTINUE
374      C
375      C TEST RESPONSE TIME, IF NOT SATISFIED, INCREASE LINE CAPACITY
376      C
377      CALL RSPTST(KL,LL,LINNEW,IOK)
378      IF(IOK .EQ. 1) GOTO 3001
379      C
380      C IF LINE TYPE IS THE HIGHEST, NO NEED TO GO FURTHER
381      C
382      IF(LINNEW .EQ. N3) GOTO 132
383      LDUMMY(LINNEW)=0
384      LINNEW=LINNEW+1
385      IF(LINCAP(LINNEW) .EQ. 9600) GOTO 132
386      LDUMMY(LINNEW)=1
387      NLNEW=1
388      CALL RHOFUN(TRFIN,TRFOUT,LDUMMY,LINNEW,RHOLIN,RHO)
389      GOTO 3000
390      3001 CONTINUE
391      IF(LINNEW.EQ.LINOLD.AND.NLOLD.EQ.1) GOTO 131
392      CALL LCOSTK(IRSC,LL,1,MCOSTL) ANEW COST FOR SUBNET UNDER LL
393      131 CONTINUE
394      LINOLD=COSTEW(KL,2)
395      MCOSTK=COSTEW(KL,1)
396      NLOLD=COSTEW(KL,3)
397      IF(LINNEW .EQ. LINOLD .AND. NLOLD .EQ. 1) GOTO 133
398      CALL LCOSTK(IRSC,KL,0,MCOSTK) ANEW COST FOR SUBNET UNDER KL

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399      GOTO 134
400 133  CONTINUE
401      ITEMP=0
402      KADD=0
403      KCHG=2
404      CALL ISUMUP(IRSC,KL,LINNEW,ITEMP)
405      MCOSTK=MCOSTK-ITEMP
406 134  CONTINUE
407      INTRY=1  @FLAG THAT INDICATES AN ENTRY TO TRYLNK
408      JSAV=COSTEW(LL,1)+COSTEW(KL,1)-(MCOSTL+MCOSTK)
409 719  CONTINUE
410      COSTKM=0
411      KADD=0
412      CALL ISUMUP(ML,KIL,LINNEW,COSTKM)
413      ISAV=JSAV-COSTKM
414      IF (ISAV .LE. MAXSAV) GO TO 132
415      RSPMAX=RSPTIM
416      MAXSAV=ISAV
417      MAXK=KL
418      MAXL=LL
419      MAXM=ML
420      MAXKI=KIL
421      MAXLINE=LINNEW
422      MAXNOL=NLNEW
423      RHOMAX=RHO
424 132  CONTINUE
425      RETURN
426      SUBROUTINE LCOSTK(I,NA,NB,TCOST)
427  C      *****
428  C
429  C      FIND COST FOR A SUBNETWORK. NA=BEGINNING NODE FOR THE SUBNET
430  C      TO BE EVALUATED.
431  C      NR=1 WHEN COST FOR CENTRAL LINK NA IS TO BE INCLUDED
432  C      NR=0 WHEN COST FOR CENTRAL LINK NA IS NOT TO BE INCLUDED
433  C
434  C      *****
435      INTEGER TCOST
436      TCOST=0
437      KCHG=2
438      CALL ISUMUP(I,NA,LINNEW,TCOST)
439  C
440  C      START COMPUTING SUBNET COST
441  C
442      JSON=IARRAY(NA,2)  @ FIRST SUCCESSOR
443      IF(JSON.EQ.0) GOTO 400
444 300  CONTINUE
445      JPA=IARRAY(JSON,5)
446      CALL ISUMUP(JPA,JSON,LINNEW,TCOST)
447      JSON=NXTNOD(NA,JSON)
448      IF (JSON .EQ. 0) GO TO 400  @ CALL IT AN END
449      GO TO 300
450 400  CONTINUE
451      IF(NB .EQ. 1) RETURN
452      ITEMP=0
453      KADD=0
454      CALL ISUMUP(I,NA,LINNEW,ITEMP)
455      TCOST=TCOST-ITEMP

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456      RETURN
457      FUNCTION NXTNOD(L1,M1)
458      C      *****
459      C
460      C      FIND THE NEXT NODE IN THE SUBNET L1 WHICH M1 BELONGS TO.
461      C      IN THE PROCESS, IF THE NEXT NODE IS L1, 0 IS RETURNED
462      C      OTHERWISE THE NEXT NODE IS RETURNED.
463      C
464      C      *****
465      C      NXTNOD=0
466      C      MM=M1
467      C      KSON=IARRAY(MM,2)
468      C      IF (KSON .EQ. 0 .AND. MM .EQ. L1) RETURN 0A SINGLE NODE
469      C      IF (KSON .EQ. 0) GO TO 1      0 NO SUCCESSOR
470      C      NXTNOD=KSON
471      C      RETURN
472      C      CONTINUE
473      C
474      C      LOOK FOR HIS NEXT BROTHER
475      C
476      C      KBRO=IARRAY(MM,3)
477      C      IF (KBRO .EQ. 0) GO TO 2      0NO MORE SUCCESSORS WITH SAME PREDECESSOR
478      C      NXTNOD=KBRO
479      C      RETURN
480      C      CONTINUE
481      C
482      C      GO TO HIS FATHER
483      C
484      C      MM=IARRAY(MM,5)
485      C      IF (MM .NE. L1) GO TO 1      0 BACK TO THE BEGINNING
486      C      RETURN
487      C      SUBROUTINE UPNETW
488      C      *****
489      C
490      C      UPDATE IARRAY AND COSTEW BASED ON MAXIMUM-AVING
491      C      PARAMETERS OBTAINED
492      C
493      C      UPDATE TRAFFIC AND NO. OF TERMINALS FOR L-SUBNET
494      C
495      C      *****
496      C      NOK=IARRAY(MAXK,1)+1 0NO. OF NODES BELOW MAXK
497      C      IARRAY(MAXL,1)=IARRAY(MAXL,1)+NOK
498      C      ARRAY(MAXL,1)=ARRAY(MAXL,1)+ARRAY(MAXK,1)
499      C      ARRAY(MAXL,2)=ARRAY(MAXL,2)+ARRAY(MAXK,2)
500      C
501      C      UPDATE THE COSTEW
502      C
503      C      COSTEW(MAXL,1)=COSTEW(MAXL,1)+COSTEW(MAXK,1)-MAXSAV
504      C      COSTEW(MAXL,2)=MAXLIN
505      C      COSTEW(MAXL,3)=MAXNOL
506      C      COSTEW(MAXK,1)=0
507      C      COSTEW(MAXK,2)=0
508      C      COSTEW(MAXK,3)=0
509      C      MAXKD=NUMR(MAXK)
510      C      MAXMD=NUMR(MAXM)
511      C      MAXKID=NUMR(MAXKI)
512      C      COSTEW(MAXL,4)=COSTEW(MAXL,4)+COSTEW(MAXK,4)+DIST(MAXKI,MAXMD)

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513      *      -DIST(MAXKD,NN1)
514      RHOF(MAXL)=RHOMAX
515      COSTEW(MAXK,4)=0
516      C
517      C UPDATE MULTIDROPPED-LINE RESPONSE TIME
518      C
519      TIMRSP(MAXL)=RSPMAX
520      91      CONTINUE
521      KIPA=IARRAY(MAXKI,5) @REMEMBER KI'S PREDECESSOR
522      MSON=IARRAY(MAXM,2) @M'S 1ST SUCCESSOR
523      CALL LNKOFF(MAXKI) @DELETE KI AS A SUCCESSOR OF KIPA
524      IARRAY(MAXM,2)=MAXKI
525      IARRAY(MAXKI,5)=MAXM
526      IARRAY(MAXKI,3)=MSON
527      IF(MSON .NE. 0) IARRAY(MSON,4)=MAXKI
528      IARRAY(MAXKI,4)=0
529      MAXM=MAXKI
530      MAXKI=KIPA
531      IF(MAXM .NE. MAXK) GOTO 91
532      RETURN
533      FUNCTION JCOSTA(N,KREF)
534      *****
535      C
536      C FIND PARTIAL SUM FOR ICSTLN
537      C
538      *****
539      JCOSTA=0
540      DO 777 K1=1,KREF
541      JCOSTA=JCOSTA+ICSTLN(K1,N)
542      777      CONTINUE
543      RETURN
544      FUNCTION JCOSTB(N,M,KREF)
545      *****
546      C
547      C FIND PARTIAL SUM FOR ICSTHW
548      C
549      *****
550      JCOSTB=0
551      DO 778 KK=1,KREF
552      JCOSTB=JCOSTB+ICSTHW(KK,N,M)
553      778      CONTINUE
554      RETURN
555      SUBROUTINE NETPRT
556      *****
557      C
558      C PRINT OUT CONFIGURATION OF THE MULTIDROP NETWORK
559      C
560      C
561      *****
562      DO 196 KK=1,NP1
563      IBLANK(KK)=JBLANK
564      196      CONTINUE
565      NN2=NUMRR(IRSC)
566      WRITE(IWT,197) NN2
567      197      FORMAT(1H1,' REGIONAL CENTER= ',A4//,6X,'SURNETWORK'//,6X,
568      * 'BEGINS AT',//)
569      KP=1
570      ISON=IARRAY(IRSC,2)

```



```

570      IPOINT=ISON
571      ISONR=NUMRR(ISON)
572      WRITE(IWT,192) (IRLANK(I),I=1,KP),ISONR
573      C
574      C LOOK FOR ITS FIRST SUCCESSOR
575      C
576      190  CONTINUE
577      ISON=IARRAY(IPOINT,2)  QCURRENT NODAL INDEX
578      IF(ISON.EQ. 0) GOTO 191 AND MORE SON
579      KP=KP + 1 QA LEVEL DEEPER
580      ISONR=NUMRR(ISON)
581      WRITE(IWT,192) (IRLANK(I),I=1,KP),ISONR
582      192  FORMAT(1X,24(A6))
583      IPOINT=ISON
584      GOTO 190
585      191  CONTINUE
586      C
587      C LOOK FOR NEXT SUCCESSOR WITH THE SAME PREDECESSOR
588      C
589      IBRO=IARRAY(IPOINT,3)
590      IF(IBRO.EQ. 0) GOTO 193
591      IBROR=NUMRR(IBRO)
592      WRITE(IWT,192) (IBLANK(I),I=1,KP),IBROR
593      IPOINT=IBRO
594      GOTO 190
595      193  CONTINUE
596      C
597      C NEXT LEVEL UP
598      C
599      KP=KP-1
600      IPOINT=IARRAY(IPOINT,5)
601      IF(KP.EQ. 0) GOTO 194 AND NEED TO GO FURTHER
602      GO TO 191
603      194  CONTINUE
604      RETURN
605      SUBROUTINE CONVRT(ICOST)
606      *****
607      C
608      C CONVERT A NUMBER INTO ITS FIELD EQUIVALENT
609      C
610      C *****
611      JCHAR(1)=JRLANK
612      JCHAR(2)=JRLANK
613      IF(ICOST.EQ. 0) GOTO 916
614      ENCODE(198,JCHAR) ICOST
615      198  FORMAT(I8)
616      916  CONTINUE
617      RETURN
618      SUBROUTINE SUMPRT(NREF,NN)
619      *****
620      C
621      C SUM UP COSTS AND PRINTS
622      C
623      C *****
624      TCOST1=0
625      TCOST2=0
626      DO 779 K=1,NREF

```

```

627      ITCOST(K,1)=ICSTLN(K,1)
628      ITCOST(K,2)=ICSTLN(K,2)
629      DO 7791 KK=1,N4
630          ITCOST(K,1)=ITCOST(K,1)+ICSTHW(K,KK,1)
631          ITCOST(K,2)=ITCOST(K,2)+ICSTHW(K,KK,2)
632 7791  CONTINUE
633      TCOST1=TCOST1+ITCOST(K,1)
634      TCOST2=TCOST2+ITCOST(K,2)
635 779  CONTINUE
636      KCOST=TCOST1+TCOST2
637  C
638  C PRINT OUT COST
639  C
640      NTURN=NREF/10+1
641      IREM=MOD(NREF,10)
642      IF (IREM .EQ. 0) NTURN=NTURN-1
643      LPAGE=1
644      DO 919 KW=1,NTURN
645          KWL=10*(KW-1)+1
646          KWU=10*KW
647          IF (KWU.GT.NREF) KWU=NREF
648          IF (NN .EQ. 0) GOTO A79
649          IF (LPAGE.NE.1) GOTO 9033
650          WRITE(IWT,9031) KW
651 9031  FORMAT('1',40X,'REGIONAL STAR NETWORK AND ITS COSTS-',I2)
652          GOTO 9035
653 9033  CONTINUE
654          WRITE(IWT,9034) KW
655 9034  FORMAT(/,40X,'REGIONAL STAR NETWORK AND ITS COSTS-',I2)
656 9035  CONTINUE
657          WRITE(IWT,9032) (NUMRR(I),I=KWL,KWU)
658 9032  FORMAT(/,1X,'SYSTEM TERMN.',15X,10(4X,A4,1X))
659          WRITE(IWT,903)
660 903   FORMAT(/,1X,'NO. OF LINES REG. ')
661          DO 1903 NJ=1,N3
662              IF (LINMIX(NJ) .EQ. 0) GOTO 1903
663              WRITE(IWT,904) LINAME(NJ), (N LINES(K,NJ), K=KWL,KWU)
664 904   FORMAT(7X,A6,14X,10(18,1X))
665 1903  CONTINUE
666          WRITE(IWT,9036) (RHOF(NJ), NJ=KWL,KWU)
667 9036  FORMAT(/,1X,'LINE UTILIZATION',11X,10(F8.3,1X))
668          WRITE(IWT,906) (IDST(N), N=KWL,KWU)
669 906   FORMAT(/,1X,'DSTNCE FROM RSC',11X,10(18,1X))
670          GO TO 806
671 879   CONTINUE
672          IF (LPAGE.NE.1) GOTO 8033
673          WRITE(IWT,8031) KW
674 8031  FORMAT('1',40X,'FINAL MULTIDROP NETWORK AND ITS COSTS-',I2)
675          GOTO 8035
676 8033  CONTINUE
677          WRITE(IWT,8034) KW
678 8034  FORMAT(/,40X,'FINAL MULTIDROP NETWORK AND ITS COSTS-',I2)
679 8035  CONTINUE
680          WRITE(IWT,803) (I, I=KWL,KWU)
681 803   FORMAT(/,1X,'SURNET NO.',16X,10(18,1X))
682          DO 1803 N=KWL,KWU
683              ID=NSUR(N)

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584      MSUB(N)=NUMRR(ID)
585      LSUB(N)=IARRAY(ID,1)+1
586      1803 CONTINUE
587      WRITE(IWT,1806) (MSUB(N),N=KWL,KWU)
588      1806 FORMAT(/,1X,'BEGINNING NODE',11X,10(4X,A4,1X))
589      WRITE(IWT,1807) (LSUB(N),N=KWL,KWU)
590      1807 FORMAT(3X,'NO. OF TERM.',12X,10(1A,1X))
591      WRITE(IWT,811)
592      811 FORMAT(3X,'NO. OF LINES')
593      DO 1808 NJ=1,N3
594      IF(LINMIX(NJ).EQ.0) GOTO 1808
595      WRITE(IWT,904) LINAME(NJ), (NLINES(K,NJ),K=KWL,KWU)
596      1808 CONTINUE
597      WRITE(IWT,8036) (RHOF(NJ),NJ=KWL,KWU)
598      8036 FORMAT(3X,'LINE UTILIZATION',9X,10(F8.3,1X))
599      WRITE(IWT,808) (IDST(N),N=KWL,KWU)
700      808 FORMAT(3X,'TOTAL MILAGE',12X,10(1A,1X))
701      806 CONTINUE
702      DO 1101 N=KWL,KWU
703      ID=N
704      IF(NN.FQ.0) ID=NSUB(N)
705      TRFSUM(N,1)=ARRAY(ID,1)
706      TRFSUM(N,2)=ARRAY(ID,2)
707      TIMOUT(N)=TIMRSP(ID)
708      1101 CONTINUE
709      WRITE(IWT,1102) (TRFSUM(N,1),N=KWL,KWU)
710      1102 FORMAT(3X,'TRAFFIC',/,3X,' LINE TO CPU',11X,10(F8.3,1X))
711      WRITE(IWT,1103) (TRFSUM(N,2),N=KWL,KWU)
712      1103 FORMAT(3X,' CPU TO LINE ',10X,10(F8.3,1X))
713      WRITE(IWT,1104) (TIMOUT(N),N=KWL,KWU)
714      1104 FORMAT(3X,'LINE RESPONSE TIME',7X,10(F8.3,1X))
715      WRITE(IWT,907)
716      907 FORMAT(21X,'SUBTOTAL',/,1X,'INST. COSTS')
717      COST=JCOSTA(1,NREF)
718      IF(KW.NE.1) COST=0
719      CALL CONVRT(COST)
720      WRITE(IWT,908) (JCHAR(L),L=1,2), (ICSTLN(NODE,1),NODE=KWL,KWU)
721      908 FORMAT(5X,'LINES',8X,A6,A2,1X,10(1A,1X))
722      DO 1909 K=1,N4
723      COST=JCOSTB(K,1,NREF)
724      IF(KW.NE.1) COST=0
725      CALL CONVRT(COST)
726      WRITE(IWT,909) NAMEHW(K), (JCHAR(L),L=1,2), (ICSTHW(NODE,K,1),
727      * NODE=KWL,KWU)
728      909 FORMAT(5X,A6,7X,A6,A2,1X,10(1A,1X))
729      1909 CONTINUE
730      WRITE(IWT,910)
731      910 FORMAT(1X,'ANNUAL RECURR. COST')
732      COST=JCOSTA(2,NREF)
733      IF(KW.NE.1) COST=0
734      CALL CONVRT(COST)
735      WRITE(IWT,908) (JCHAR(L),L=1,2), (ICSTLN(NODE,2),NODE=KWL,KWU)
736      DO 1911 K=1,N4
737      COST=JCOSTB(K,2,NREF)
738      IF(KW.NE.1) COST=0
739      CALL CONVRT(COST)
740      WRITE(IWT,909) NAMEHW(K), (JCHAR(L),L=1,2), (ICSTHW(NODE,K,2),

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741      * NODE=KWL,KWU)
742 1911 CONTINUE
743      WRITE(IWT,912)
744 912  FORMAT(1X,'TOTAL COST')
745      IF(KW.NE.1) TCOST1=0
746      CALL CONVRT(TCOST1)
747      WRITE(IWT,913) (JCHAR(L),L=1,2),(ITCOST(K,1),K=KWL,KWU)
748      IF(KW.NE.1) TCOST2=0
749      CALL CONVRT(TCOST2)
750      WRITE(IWT,914) (JCHAR(L),L=1,2),(ITCOST(K,2),K=KWL,KWU)
751 913  FORMAT(4X,'INST. COST',4X,A6,A2,1X,10(19,1X))
752 914  FORMAT(4X,'RECUR. COST',3X,A6,A2,1X,10(19,1X))
753      LPAGE=LPAGE+1
754      LPAGE=MOD(LPAGE,2)
755 919  CONTINUE
756      WRITE(IWT,695) KCOST
757 695  FORMAT(/,25X,'TOTAL COST=',I8)
758      RETURN
759      SUBROUTINE MUTDRP
760      C *****
761      C
762      C PRINT OUT FINAL MULTIDROP NETWORK WITH ITS COSTS
763      C
764      C *****
765      DO 590 NL=1,N3
766          LDUMMY(NL)=0
767 590  CONTINUE
768      IBRO=IARRAY(IRSC,2) @FIRST SUCCESSOR
769      K1=1
770 699  CONTINUE
771      IF(IBRO.EQ.0) GOTO 698
772      NK2=NUMR(IBRO)
773      NK1=NN1
774      NSUB(K1)=IBRO
775      LINE=COSTEW(IBRO,2)
776      LDUMMY(LINE)=COSTEW(IBRO,3)
777      JSON=IARRAY(IPRO,2)
778      IF(JSON.EQ.0) GOTO 694
779      DO 592 NM=1,2
780          ICSTLN(K1,NM)=0
781          DO 592 NK=1,N4
782              ICSTHW(K1,NK,NM)=0
783 592  CONTINUE
784      DO 596 NL=1,N3
785          NLINES(K1,NL)=LDUMMY(NL)
786 596  CONTINUE
787      KCHG=2
788 312  CONTINUE
789      CALL ICOSTJ(LDUMMY,NK1,NK2,LNKCHW,1,NKCLN)
790      DO 595 NL=1,N3
791          DO 595 NM=1,2
792              ICSTLN(K1,NM)=ICSTLN(K1,NM)+LNKCLN(NL,NM)
793          DO 595 NK=1,N4
794              ICSTHW(K1,NK,NM)=ICSTHW(K1,NK,NM)+LNKCHW(NL,NK,NM)
795 595  CONTINUE
796      IF(JSON.EQ.0) GOTO 311
797      NK2=NUMR(JSON) @GLOBAL INDEX FOR NEXT NODE

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798      NK1=IARRAY(JSON,5) @PREDECESSOR
799      NK1=NUMR(NK1) @GLOBAL INDEX FOR PREDECESSOR
800      JSON=NXTNOD(IBRO,JSON)
801      GOTO 312
802 311  CONTINUE
803      LDUMMY(LINE)=0
804      GOTO 591
805 694  CONTINUE
806  C
807  C USE PREVIOUS DATA
808  C
809      DO 597 NL=1,N3
810          NLINES(K1,NL)=NLINES(IBRO,NL)
811 597  CONTINUE
812      DO 598 NM=1,2
813          ICSTLN(K1,NM)=ICSTLN(IBRO,NM)
814      DO 598 NK=1,N4
815          ICSTHW(K1,NK,NM)=ICSTHW(IBRO,NK,NM)
816 598  CONTINUE
817      LDUMMY(LINE)=0
818 591  CONTINUE
819      INST(K1)=COSTEW(IBRO,4)
820      RHOF(K1)=RHOF(IBRO) @SHUFFLING RHO'S DUE TO RE-INDEXING
821      IBRO=IARRAY(IBRO,3)
822      K1=K1+1
823      GOTO 699
824 698  CONTINUE
825      NOSUB=K1-1
826      CALL SUMPRT(NOSUB,0)
827      RETURN
828      SUBROUTINE CALPLT
829          *****
830  C
831  C PLOT A MULTIDROP NETWORK
832  C
833      *****
834      KP=1
835      IPOINT=IRSC
836      CALL TRSFRM(2)
837      ISON=IARRAY(IRSC,2) @FIRST SUCCESSOR
838      IPOINT=ISON
839      CALL TPSFRM(1)
840  C
841  C LOOK FOR ITS FIRST SUCCESSOR
842  C
843 190  CONTINUE
844      ISON=IARRAY(IPOINT,2) @FIRST SUCCESSOR
845      IF (ISON .EQ. 0) GOTO 191
846      KP=KP+1
847      IPOINT=ISON
848      CALL TRSFRM(1)
849      GOTO 190
850 191  CONTINUE
851  C
852  C LOOK FOR ITS NEXT SUCCESSOR
853  C
854      IBRO=IARRAY(IPOINT,3)

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855      IPOINT=IARRAY(IPOINT,5)  QNOW ITS PREDECESSOR
856      CALL TRSFRM(2)
857      IF(IBRO .EQ. 0) GOTO 193
858      IPOINT=IBRO
859      CALL TRSFRM(1)
860      GOTO 190
861 193  CONTINUE
862  C
863  C GO BACK TO ITS PREDECESSOR
864  C
865      KP=KP-1
866      IF(KP .EQ. 0) GOTO 194
867      GOTO 191
868 194  CONTINUE
869      CALL TRSFRM(3)
870      RETURN
871      SUBROUTINE TRSFRM(LK)
872  C      *****
873  C
874  C FIND GLOBAL MAPADR INDEX FOR V-H COORDINATES AND PID NO
875  C
876  C      *****
877      DATA IP/0/
878      IF(LK .EQ. 3) GOTO 666
879      LK1=NUMR(IPOINT)  QGLOBAL INDEX
880      IDD=MAPADR(LK1)  QMAPADR INDEX FOR LK1
881      IF(IDD .EQ. IP) RETURN
882      IP=IDD
883 666  CONTINUE
884      CALL PLOTPT(IDD,LK)
885      RETURN
886      SUBROUTINE LNKOFF(MP)
887  C      *****
888  C
889  C DELETE MP AS A SUCCESSOR OF NODE PA
890  C
891  C      *****
892      IFRONT=IARRAY(MP,4)  QTHE SUCCESSOR BEFORE MP
893      IBACK =IARRAY(MP,3)  QTHE SUCCESSOR AFTER MP
894      IF(IFRONT .NE. 0) GOTO 92
895      MPA=IARRAY(MP,5)
896      IARRAY(MPA,2)= IBACK  Q1ST SUCCESSOR UNDER NEW MPA
897      GOTO 99
898 92  CONTINUE
899      IARRAY(IFRONT,3)=IBACK
900 99  CONTINUE
901      IF(IBACK .EQ. 0) RETURN
902      IARRAY(IBACK,4)=IFRONT
903      RETURN
904      SUBROUTINE RSPTST(KKK,LLL,LINMAX,IOK)
905  C      *****
906  C
907  C TEST RESPONSE TIME, SATISFIED WHEN IOK=1
908  C
909  C      *****
910      MDROP=IARRAY(LLL,1)+IARRAY(KKK,1)+2
911      TRFIN=ARRAY(LLL,1)+ARRAY(KKK,1)
912      TRFOUT=ARRAY(LLL,2)+ARRAY(KKK,2)
913      CALL RSPNSE(TRFIN,TRFOUT,LINMAX,MDROP,IOK)
914      RETURN
915  END

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QPRT STACOM.IRNOF/0777

51928*STACOM(1).IRNOP/0777

```

1      SUBROUTINE IRNOP(NR,LIMIT,TRM)
2      C
3      C *****
4      C
5      C SUBPROGRAM FOR THE INTER-REGION NETWORK OPTIMIZATION
6      C LIMIT=MINIMAL NUMBER OF PATHS NEEDED PER REGIONAL
7      C SWITCHING CENTER
8      C
9      C *****
10     PARAMETER NP1=130,NP2=1,NP3=4,NP4=3
11     PARAMETER NPC=360, NP6=(NPC*NPC/2-NPC+1)/4+1
12     PARAMETER NP7=4, IWT=100, MW=4
13     COMMON/CONST/N1,N2,N3,N4,N7,NCITY
14     COMMON/LINCHR/LINMIX(NP3),LINCAP(NP3), UTILIZ(NP3)
15     * /BCOS/AINSTC(NP2,NP3,NP4,3,2,2),RECRC(NP2,NP3,NP4,3,2,2),
16     * ANSTLN(NP2,NP3,3,2,2),RECRLN(NP2,NP3,3,2,16),IDUPLY(NP3)
17     * /NAME/INDXPT(NP1), NAMEST(NP1),LNAME(NP3),NAMEHW(NP4)
18     * /EIN/SVR(NP1),NRSC(MW),NUMPR(MW),TRAFON(NP1),TRAFIT(NP1)
19     * /REF/IREF(NPC),TRAFO(NP1,2,NP7),DSTNCF(NP6),MAPADR(NP1)
20     DIMENSION NETSUM(NP3,2),ORINET(MW,MW,NP3)
21     DIMENSION NLINK(NP3),LNKCHW(NP3,NP4,2),LNKCLN(NP3,2)
22     INTEGER SUMCST
23     INTEGER ORINET
24     DIMENSION TRM(MW,MW),TR(MW,MW)
25     INTEGER ORICST,ORICS1,ORICS2
26     INTEGER DIVTRI(MW),DIVTRJ(MW)
27     DIMENSION TRR(MW,MW),NETCNF(MW,MW,NP3),LINEQU(NP3),
28     * LINADI(NP3),LINADJ(NP3),ILINAD(NP3),JLINAD(NP3),
29     * LINEQ(NP3),LINEQA(NP3),LINEQR(NP3)
30     DIMENSION RHOF2(MW,MW)
31     DIMENSION TRM(MW,MW)
32     EQUIVALENCE (LINEQ,LINEQA),(LINEQU,LINEQR)
33     C
34     C RFSET UTILIZATION FACTOR TO .5
35     C
36     DO 70 NN1=1,N3
37     UTILIZ(NN1)=.5
38     70 CONTINUE
39     C
40     C COMPUTE ORINET(MW,MW,N3) FOR INITIAL TOPOLOGY WHERE N3 IS
41     C THE NUMBER OF CHARGEABLE ITEMS
42     C
43     ORICST=0
44     ORICS1=0
45     ORICS2=0
46     NR1=NR-1
47     DO 203 NN1=1,N3
48     DO 203 NN2=1,2
49     NETSUM(NN1,NN2)=0 DCOST SUM
50     203 CONTINUE
51     C
52     C MODIFY DUPLEXING MODE FROM HALF TO FULL DUPLEX
53     C
54     DO 667 K1=1,N3
55     IDUPLX(K1)=2
56     667 CONTINUE
57     DO 101 I=1,NR1

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57      NLINK(I)=NR1  QNR1 LINKS AT THE BEGINNING
58      I1=I+1
59      DO 102 J=I1,NR
60      II=NRSC(I)
61      JJ=NRSC(J)
62      ATRMAX=AMAX1(TR(I,J), TR(J,I))  QASSUMING FULL DUPLEX
63      CALL LINNUM (ATRMAX,0.,LINEQ,LINUP,0,RHO)
64      RHOF2(I,J)=RHO
65      RHOF2(J,I)=RHO
66      CALL ICOSTJ(LINEQ,II,JJ, LNKCHW,LN,CLN)
67      DO 104 NN=1,N3
68      ORINET(I,J,NN)= LINEQ(NN)
69      ORINET(J,I,NN)= LINEQ(NN)
70      DO 105 NM=1,N2  Q LINE COST
71      NETSUM(NN,NM)= NETSUM(NN,NM)+ LNKCLN(NN,NM)
72      DO 106 NK=1,N4  Q HARDWARE COSTS
73      NETSUM(NN,NM)= NETSUM(NN,NM)+ LNKCHW(NN,NK,NM)
74      106 CONTINUE
75      105 CONTINUE
76      104 CONTINUE
77      102 CONTINUE
78      101 CONTINUE
79      DO 107 K1=1,NR
80      DO 107 NN=1,N3
81      ORINET(K1,K1,NN)=0
82      107 CONTINUE
83      CALL OUTPRT(1)
84      ITALLY=0
85      999 CONTINUE
86      MAXSAV=0
87      DO 777 I=1,NR1
88      IF (NLINK(I) .LE. LIMIT) GO TO 777
89      I1=I+1
90      DO 788 J=I1,NR
91      IF (NLINK(J) .LE. LIMIT) GO TO 788
92      IN=NTST(ORINET,I,J)
93      IF (IN .EQ. 0) GO TO 788  QNO LINK TO BE DELETED
94      C
95      C DETERMINE WHETHER THERE IS A LINK CONNECTED BY AT MOST ONE INDIRECT
96      C ROUTE BETWEEN ANY TWO REGIONS IN THE NETWORK WHEN THE DIRECT LINK
97      C BETWEEN I AND J IS ELIMINATED. THE INDIRECT LINK ONLY GOES THROUGH
98      C ONE INTERMEDIATE RSC.
99      C
100      DO 139 L=1,NR1
101      L1=L+1
102      DO 138 M=L1,NR
103      IY=ITEST(I,J,L,M)
104      IF (IY .EQ. 1) GO TO 810  QNEXT STEP NOT TO BE TESTED
105      IN=NTST(ORINET,L,M)
106      IF (IN .EQ. 1) GO TO 138
107      810 CONTINUE
108      DO 137 N=1,NR
109      IF (L .EQ. N) GO TO 137
110      IY=ITEST(I,J,L,N)
111      IF (IY .EQ. 1) GOTO 137
112      IN=NTST(ORINET,L,N)
113      IF (IN .EQ. 0) GO TO 137

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114      IV=ITEST(I,J,N,M)
115      IF (IV .EQ. 1) GOTO 137
116      IN=NTTEST(ORINET,M,N)
117      IF (IN .EQ. 1) GO TO 138
118      137 CONTINUE
119      GO TO 788
120      138 CONTINUE
121      139 CONTINUE
122      SDIVTI=0
123      SDIVTJ=0
124      CALL TRFDIV(IFLOP)
125      IF (IFLOP .EQ. 1) GO TO 201
126      CALL MINAD(IIAD,MINCST)
127      GO TO 202
128      201 CONTINUE
129      CALL NETWKC(MINCST)
130      202 CONTINUE
131      ISAV=ORICST-MINCST
132      IF (MAXSAV .GE. ISAV) GO TO 788
133      MAXSAV=ISAV
134      IFLIP=IFLOP @IFLIP=GLOBAL INDICATOR
135      IF (IFLOP .EQ. 1) GO TO 204
136      IIMAX=IIAD
137      IMAX=I
138      JMAX=J
139      DO 666 NN=1,N3
140      ILINAD(NN)= LINADI(NN) @CHANGE OF LINE REQ.
141      JLINAD(NN)= LINADJ(NN)
142      666 CONTINUE
143      204 CONTINUE
144      DO 331 K1=1,NR
145      DO 331 K2=1,NR
146      TRRM(K1,K2)=TRR(K1,K2)
147      331 CONTINUE
148      788 CONTINUE
149      777 CONTINUE
150      IF (MAXSAV .LE. 0) GO TO 9999
151      CALL NETUP(IFLIP,IIMAX,IMAX,JMAX)
152      ITALLY=ITALLY+1
153      GO TO 999
154      9999 CONTINUE
155      109 FORMAT(1X,' THIS NETWORK HAS BEEN UPDATED FOR ',I5,' TIMES',///)
156      WRITE(6,109) ITALLY
157      DO 81 I=1,N3
158      DO 81 J=1,2
159      NETSUM(I,J)=0
160      81 CONTINUE
161      DO 91 I=1,NR1
162      K=I+1
163      DO 92 J=K,NR
164      DO 93 K1=1,N3
165      LINEQ(K1)=ORINET(I,J,K1)
166      93 CONTINUE
167      II=NRSC(I)
168      JJ=NRSC(J)
169      CALL ICOSTJ(LINEQ,II,JJ,LNKCHW,LNKCLN)
170      DO 94 KK=1,N3

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171      NETSUM(KK,1)=NETSUM(KK,1)+LNKCLN(KK,1)
172      NETSUM(KK,2)=NETSUM(KK,2)+LNKCLN(KK,2)
173      DO 95 KL=1,N4
174      NETSUM(KK,1)=NETSUM(KK,1) + LNKCHW(KK,KL,1)
175      NETSUM(KK,2)=NETSUM(KK,2) + LNKCHW(KK,KL,2)
176      95  CONTINUE
177      94  CONTINUE
178      92  CONTINUE
179      91  CONTINUE
180      ORICS1=0
181      ORICS2=0
182      CALL OUTPRT(2)
183      RETURN
184      SUBROUTINE OUTPRT(N)
185      C      *****
186      C
187      C PRINT OUT INTERREGIONAL NETWORK CONFIGURATION AND ITS COSTS
188      C
189      C      *****
190      DO 110 I=1,N3
191      ORICS1=ORICS1+NETSUM(I,1)
192      ORICS2=ORICS2+NETSUM(I,2)
193      110  CONTINUE
194      NTURN=NR/10+1
195      DO 2001 L=1,NTURN
196      LL=(NTURN-1)*10 + 1
197      LU=NTURN*10
198      IF(LU .GT. NR) LU=NR
199      IF(N .EQ. 2) GOTO 2100
200      WRITE(IWT,2002) (J,J=LL,LU)
201      2002 FORMAT('1,///,10X,'INITIAL INTERREGIONAL NETWORK CONFIGURATION',
202      * ///,20X,10(5X,I3,2X))
203      GOTO 2101
204      2100  CONTINUE
205      WRITE(IWT,2102) (J,J=LL,LU)
206      2102 FORMAT('1,10X,'FINAL OPTIMAL INTERREGIONAL NETWORK CONFIGURATION',
207      * ///,20X,10(5X,I3,2X))
208      2101  CONTINUE
209      DO 2003 I=1,NR
210      WRITE(IWT,2004) I
211      2004  FORMAT(' REGION',/,I4)
212      DO 2108 M=1,N3
213      WRITE(IWT,2008) LNAME(M), (ORINF(I,K,M),K=LL,LU)
214      2108  CONTINUE
215      2008  FORMAT('4X,A6,10X,10(5X,I3,2X))')
216      WRITE(IWT,2201) (RHOF2(I,J),J=LL,LU)
217      2201  FORMAT('4X,'LINE UTILIZATION',10(4X,F4.3,2X))
218      2003  CONTINUE
219      2001  CONTINUE
220      WRITE(IWT,2006)
221      2006  FORMAT('///,17X,'INST. COST',7X,'RECUP. COST',9X,'SUBTOTAL')
222      DO 2005 K=1,N3
223      ISUM=NETSUM(K,1)+NETSUM(K,2)
224      WRITE(IWT,2007) K,LNAME(K), (NETSUM(K,I),I=1,2), ISUM
225      2007  FORMAT('///,15,3X,A6,5X,I6,11X,I6,10X,I8)
226      2005  CONTINUE
227      ORICST=ORICS1+ORICS2

```

```

228      WRITE(IWT,2009) ORICS1,ORICS2,ORICS3
229 2009  FORMAT(//,9X,'TOTAL',4X,I7,10X,I7,10X,I7)
230      RETURN
231      FUNCTION ITEST(I,J,K,L)
232      C *****
233      C
234      C TEST EQUIVALENCE BETWEEN SUBSET(I,J) AND SUBSET(K,L)
235      C
236      C *****
237      ITEST=0
238      IF (I .EQ. K .AND. J .EQ. L) ITEST=1
239      IF (I .EQ. L .AND. J .EQ. K) ITEST=1
240      RETURN
241      FUNCTION NTEST(NET,I,J)
242      C *****
243      C
244      C TEST DIRECT LINE CONNECTIVITY BETWEEN I AND J.
245      C
246      C *****
247      DIMENSION NET(MW,MW,NP3)
248      DO 103 I1=1,N3
249      IF (NET(I,J,I1) .GT. 0) GO TO 108
250 103  CONTINUE
251      NTEST=0      @ NO CONNECTION
252      RETURN
253 108  NTEST=1
254      RETURN      @ YES, THERE IS A CONNECTION
255      SUBROUTINE TRFDIV(IFLOP)
256      C *****
257      C
258      C DIVERT TRAFFIC BETWEEN I AND J THROUGH OTHER RSCS.
259      C
260      C *****
261      C
262      C IT RETURNS WITH IFLOP=1 WHEN SUCCESSFUL I OTHERWISE IFLOP=0.
263      C IT ALSO CREATES TEMPORARY MATRICES TRR AND NETCNF.
264      C
265      SNIVTI=0. @TOTAL TRAFFIC DIVERTED (I TO J)
266      SNIVTJ=0. @TOTAL TRAFFIC DIVERTED (J TO I)
267      DO 205 K=1,NR
268      DIVTRI(K)=0. @ TRAFFIC DIVERTED THRU REGION K (I TO J)
269      DIVTRJ(K)=0. @ TRAFFIC DIVERTED THRU REGION K (J TO I)
270 205  CONTINUE
271      DO 220 I1=1,NR
272      IF (I1.EQ.I.OR.I1.EQ.J) GO TO 220
273      IC1=NTEST(ORINET,I,I1)
274      IC2=NTEST(ORINET,I1,J)
275      IF (IC1.EQ.0 .OR. IC2.EQ.0) GO TO 220
276      C
277      C DIVERT I TO J TRAFFIC THRU I1
278      C
279      DIVTRI(I1)=0.
280      DIVTRJ(I1)=0.
281      CALL LINTRF(I,I1,A)
282      DELTR= A-TR(I,I1)
283      IF (DELTR.LE.0.0) GO TO 160
284      C

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```

285      DIVTR=DELTR
286      CALL LINTRF(II,J,A)
287      DELTR= B-TR(II,J)
288      IF (DELTR.LE.0.0) GO TO 160
289      DIVTRI(II)= AMIN1(DELTR,DIVTR)
290      IF ((DIVTRI(II)+ SDIVTI).GT.TR(I,J))GO TO 140
291      SDIVTI= SDIVTI+ DIVTRI(II)
292      GO TO 160
293      C
294      140  DIVTRI(II)= TR(I,J)- SDIVTI
295          SDIVTI= TR(I,J)
296      C
297      C    DIVERT J TO I TRAFFIC THRU II
298      C
299      160  CONTINUE
300      CALL LINTRF(J,II,A)
301      DELTR= A-TR(J,II)
302      IF (DELTR.LE.0.0) GO TO 220
303      C
304      DIVTR=DELTR
305      CALL LINTRF(II,I,B)
306      DELTR= B-TR(II,I)
307      IF (DELTR.LE.0.0) GO TO 220
308      DIVTRJ(II)= AMIN1(DELTR,DIVTR)
309      IF ((DIVTRJ(II)+ SDIVTJ).GT. TR(J,I)) GO TO 180
310      SDIVTJ= SDIVTJ+ DIVTRJ(II)
311      GO TO 200
312      C
313      180  DIVTRJ(II)= TR(J,I)- SDIVTJ
314          SDIVTJ= TR(J,I)
315      C
316      200  CONTINUE
317          IF ((SDIVTI .EQ. TR(I,J)).AND. (SDIVTJ .EQ. TR(J,I)))GO TO 340
318      220  CONTINUE
319          IFLOP=0
320          GO TO 360
321      340  IFLOP=1
322      360  CONTINUE
323      C
324      C  CREATE A NEW TRAFFIC MATRIX WHICH ELIMINATES THE TRAFFIC BETWEEN
325      C  NODES I AND J AND A TEMPORARY NETWORK NETCNF FOR THE PURPOSE
326      C  OF COST EVALUATION
327      C
328          DO 191 K1=1,NR
329          DO 191 K2=1,NR
330              TRR(K1,K2)=TR(K1,K2)
331          DO 191 K3=1,N3
332              NETCNF(K1,K2,K3)=ORINF(K1,K2,K3)
333      191  CONTINUE
334          DO 190 KI=1,N3
335              NETCNF (I,J,KI)=0
336              NETCNF (J,I,KI)=0
337              NETCNF (I,I,KI)=0
338              NETCNF (J,J,KI)=0
339      190  CONTINUE
340          TRR(I,J)=0
341          TRR(J,I)=0

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342      DO 380 IK=1,NR
343      IF (I.EQ. IK .OR. J.EQ. IK) GO TO 380
344      TRR(I,IK)= TR(I,IK)+ DIVTRI(IK)
345      TRR(IK,J)= TR(IK,J)+ DIVTRI(IK)
346      TRR(J,IK)= TR(J,IK)+ DIVTRJ(IK)
347      TRR(IK,I)= TR(IK,I)+ DIVTRJ(IK)
348      ATRMAX=AMAX1(TRR(I,IK),TRR(IK,I))
349      BTRMAX=AMAX1(TRR(J,IK),TRR(IK,J))
350      IOR1=NRSC(I)
351      IOR2=NRSC(IK)
352      CALL LINNUM(ATRMAX,0.,LINEQ,LINUP,0,RHO)
353      RHOF2(I,IK)=RHO
354      RHOF2(IK,I)=RHO
355      IOR1=NRSC(J)
356      CALL LINNUM(BTRMAX,0.,LINEQ,LINUP,0,RHO)
357      RHOF2(J,IK)=RHO
358      RHOF2(IK,J)=RHO
359      DO 430 NN=1,N3
360      NETCNF(I,IK,NN)=LINEQ(NN)
361      NETCNF(IK,I,NN)=LINEQ(NN)
362      NETCNF(IK,J,NN)=LINEQ(NN)
363      NETCNF(J,IK,NN)=LINEQ(NN)
364      430 CONTINUE
365      380 CONTINUE
366      RETURN
367      SUBROUTINE LINTRF(I,J,A)
368      C *****
369      C
370      C CONVERT LINES INTO TRAFFIC CAPACITIES BETWEEN NODES I AND J.
371      C
372      C *****
373      A=0
374      DO 100 IR=1,N3
375      A=A+ ORINET(I,J,IR)*LINCAP(IR)*UTTLI7(IR)
376      100 CONTINUE
377      RETURN
378      SUBROUTINE NETWKC(SUMCST)
379      C *****
380      C FIND TOTAL INTERREGIONAL NETWORK COST,SUMCST,BASED ON SPECIFIC
381      C CONFIGURATION NETCNF
382      C *****
383      INTEGER SUMCST
384      SUMCST=0
385      DO 420 IR=1,NR1
386      IR1=IR+1
387      DO 400 IK=IR1,NR
388      IC=NTFST(NETCNF,IR,IK)
389      IF (IC.EQ.0) GO TO 400
390      II=NRSC(IR)
391      JJ=NRSC(IK)
392      DO 150 IIT=1,N3
393      LINEQ(IIT)= NETCNF(IR,IK,IIT)
394      150 CONTINUE
395      CALL TCOSTJ(LINEQ,II,JJ,LNKCHW,LNKCLN)
396      DO 501 J1=1,N3
397      DO 510 J2=1,2
398      DO 520 J3=1,N4

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399      SUMCST=SUMCST+LNKCHW(J1,J3,J2)
400      520  CONTINUE
401      SUMCST=SUMCST+LNKCLN(I1,J2)
402      510  CONTINUE
403      501  CONTINUE
404      400  CONTINUE
405      420  CONTINUE
406      RETURN
407      SUBROUTINE MINAD(I1AD,MINCST)
408          C      *****
409          C
410          C CAPACITY INCREASE IS REQUIRED WHEN IFLOP=0. AND THE CAPACITY AT
411          C MAXIMUM COST SAVINGS.
412          C
413          C      *****
414          DIMENSION LINDI(NP3),LINDJ(NP3)
415          MINCST=0
416          RTRFI=TR(I,J)-SDIVTI QREMAINING TRAFFIC FROM I TO J
417          RTRFJ=TR(J,I)-SDIVTJ QREMAINING TRAFFIC FROM J TO I
418          DO 500 II=1,NR
419          IF(II.EQ.I.OR.II.EQ.J) GO TO 500
420          IF( TRR(I,II) .EQ.0. .OR. TRR(II,J) .EQ.0.) GO TO 500
421          C
422          C DETERMINE DELTA COST FOR INCREASED CAPACITY IN ALTERNATE ROUTES
423          C LINK (I,II)
424          C
425          AII=TRR(I,II) + RTRFI
426          AJI= TRR(II,I) +RTRFJ
427          AM= AMAX1(AII,AJI)
428          IDR1=NRSC(I)
429          IDR2=NRSC(II)
430          CALL LINNUM(AM,0.,LINEQA,LINUP,0,RHO)
431          DO 151 NN=1,N3
432          LINDI(NN)= LINEQA(NN)- NETCNF(I,II,NN)
433          NETCNF(I,II,NN)= LINEQA(NN)
434          NETCNF(II,I,NN)= LINEQA(NN)
435          151 CONTINUE
436          C
437          C LINK(II,J)
438          C
439          BII=TRR(II,J)+RTRFI
440          BJII=TRR(J,II)+RTRFJ
441          BM= AMAX1(BII,BJII)
442          IDR1=NRSC(J)
443          CALL LINNUM(BM,0.,LINEQB,LINUP,0,RHO)
444          DO 111 NN=1,N3
445          LINDJ(NN)= LINEQB(NN)- NETCNF(J,II,NN)
446          NETCNF(J,II,NN)= LINEQB(NN)
447          NETCNF(II,J,NN)= LINEQB(NN)
448          111 CONTINUE
449          CALL NETWKC(SUMCST)
450          IF (SUMCST.GT.MINCST) GO TO 120
451          DO 207 NN=1,N3
452          LINADI(NN)= LINDI(NN)
453          LINADJ(NN)= LINDJ(NN)
454          207 CONTINUE
455          I1AD =II

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456          MINCST =SUMCST
457      120  CONTINUE
458      C
459      C RESET TO INITIAL NETWORK CONFIGURATION FOR NEXT TRY
460      C
461          DO 250 NN= 1,N3
462          NETCNF(I,II,NN)= NETCNF(I,II,NN)- LINDY(NN)
463          NETCNF(II,I,NN)= NETCNF(II,I,NN)- LINDY(NN)
464          NETCNF(J,II,NN)= NETCNF(J,II,NN)- LINDJ(NN)
465          NETCNF(II,J,NN)= NETCNF(II,J,NN)- LINDJ(NN)
466      250  CONTINUE
467      500  CONTINUE
468          TRR(I,IIAD)=TRR(I,IIAD)+RTRFI
469          TRP(IIAD,J)=TRR(IIAD,J)+RTRFI
470          TRR(J,IIAD)=TRR(J,IIAD)+RTRFJ
471          TRP(IIAD,I)=TRP(IIAD,I)+RTRFJ
472          RETURN
473          SUPROUTINE NETUP(I,FLIP,IIAD,I,J)
474      C          *****
475      C
476      C UPDATE THE INTERREGIONAL NETWORK WHEN THERE IS SOME SAVINGS
477      C
478      C          *****
479      C          IF (IFLIP.FQ.1) GO TO 700
480      C
481      C          UPDATE THE NETWORK TRAFFIC MATRIX AND
482      C          UPDATE THE OPTIMAL INTERREGIONAL NETWORK
483      C
484          DO 99 NN=1,N3
485          ORINET (I,IIAD,NN)=ORINET(I,IIAD,NN)+ YLINAD(NN)
486          ORINET (IIAD,I,NN)=ORINET(IIAD,I,NN)+ YLINAD(NN)
487          ORINET (J,IIAD,NN)=ORINET(J,IIAD,NN)+ JLINAD(NN)
488          ORINET (IIAD,J,NN)=ORINET(IIAD,J,NN)+ JLINAD(NN)
489      99  CONTINUE
490      700  CONTINUE
491          DO 701 NN=1,N3
492          ORINET(I,J,NN)=0
493          ORINET(J,I,NN)=0
494      701  CONTINUE
495      C
496      C          RESET TRAFFIC MATRIX TR(NR,NR)
497      C
498          DO 900 IR= 1,NR
499          DO 910 IK= 1,NR
500          TR(IR,IK)= TRRM(IR,IK)
501      910  CONTINUE
502      900  CONTINUE
503      C
504      C UPDATE TOTAL COST FOR OVERALL NETWORK
505      C
506          ORICST=ORICST-MAXSAV
507      C
508      C UPDATE NLINK MATRIX
509      C
510          NLINK(I)=NLINK(I)-1
511          NLINK(J)=NLINK(J)-1
512          RETURN
513      END

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MPRT STACOM.ICOSTJ/0777

5192R*STACOM(1).ICOSTJ/0777

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1      SUBROUTINE ICOSTJ(LINEQU,I,J,LNKCHW,LNKCLN)
2      C
3      C *****
4      C CALCULATE INSTALLATION ANNUAL RECURRING COSTS NEEDED FOR
5      C COMMUNICATION LINK BETWEEN NODES I AND J. LNKCHW= OTHERS
6      C LNKCLN= LINES. I AND J ARE GLOBAL INDICES FOR SYSTEM TERMINATIONS
7      C UNDER CONSIDERATION. LINEQU= LINE CONFIGURATION BETWEEN I AND J
8      C
9      C *****
10     PARAMETER NP1=130, NP2=1, NP3=4, NP4=3, NPC=360
11     PARAMETER NP6=(NPC*NPC/2-NPC+1)/4+1
12     PARAMETER NP7=4
13     DIMENSION LINEQU(NP3), LNKCHW(NP3,NP4,2), LNKCLN(NP3,2)
14     COMMON/LINCHR/LINMIX(NP3), LINCAP(NP3), IITJ(IZ(NP3)
15     * /CONST/N1,N2,N3,N4,N7,NCITY
16     * /BCOST/AINSTC(NP2,NP3,NP4,3,2,2), REFCPC(NP2,NP3,NP4,3,2,2),
17     * ANSTLN(NP2,NP3,3,2,2), RECRN(NP2,NP3,3,2,16), IDUPLX(NP3)
18     * /INF/IRATEJ(NP2,NP2), IRAND(NPC,2), IFLAG(NP2,NP3)
19     * /ADD/ IADD(NP1), KCHG, KADD @TERMINALS WITH SAME V=H
20     * /REF/ IREF(NPC), TRAFD(NP1,2,NP7), DSTNCE(NP6), MAPADR(NP1)
21     C
22     C INITIALIZATION
23     C
24     II=MAPADR(I)
25     JJ=MAPADR(J)
26     IADDTN=IADD(J)
27     DO 100 NL=1,N3
28     DO 100 NM=1,2
29     LNKCLN(NL,NM)=0
30     DO 100 NK=1,N4
31     LNKCHW(NL,NK,NM)=0
32     100 CONTINUE
33     KRATEI= IRAND(II,1) @ RATE STRUCTURE TYPE FOR NODE I
34     KRATEJ= IRAND(JJ,1) @ RATE STRUCTURE TYPE FOR NODE J
35     KOENSI= IRAND(II,2) @ TRAFFIC DENSITY TYPE FOR NODE I
36     KOENSJ= IRAND(JJ,2) @ TRAFFIC DENSITY TYPE FOR NODE J
37     KDNSTY= KOENSI+KOENSJ @ ACTUAL DENSITY (2=H-H, 1=H-L AND 0=L-L)
38     KK=KDNSTY+1 @3=H-H, 2=H-L AND 1=L-L
39     DST = DIST(I,J) @ DISTANCE BETWEEN NODES I AND J
40     INST=DST
41     ITIP=1 @PRIME COST FOR H/W UNIT
42     IF(DST .LE. 0.5) ITIP=2 @DISCOUNT COST FOR ADDITIONAL UNIT
43     KP = IRATEJ(KRATEI,KRATEJ) @ ACTUAL RATE STRUCTURE TO BE USED
44     DO 1 IL= 1,N3
45     INPX= IDUPLX(IL) @ DUPLEXING MODE 1=H AND 2=L
46     NDV = LINEQU(IL) @ NUMBER OF LINES REQUIRED
47     NDV1=NDV*IADDTN*KADD
48     C
49     C CALCULATE COSTS FOR NON-LINE TYPE CHARGES
50     C
51     IF (NDV.EQ.0) GO TO 1 @ NO LINES ARE REQUIRED
52     DO 2 IV=1,N4 @HIGH DENSITY RATE
53     C
54     C INSTALLATION COSTS FOR NON-LINE TYPE CHARGES
55     C
56     LNKCHW (IL,IV,1)= AINSTC(KR,IL,IV,KK,INPX,ITIP)*KCHG*NDV

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57      1      + AINSTC(KR,IL,IV,KK,IDPX,2)*NDV1
58      C
59      C ANNUAL RECURRING COSTS FOR NON-LINE TYPE CHARGES
60      C
61      LNKCHW (IL,IV,2)=( RECRK(KR,IL,IV,KK,IDPX,ITIP)*KCHG*NDV
62      1      + RECRK(KR,IL,IV,KK,IDPX,2)*NDV))*12.
63      2      CONTINUE
64      C
65      C CALCULATE LINE COSTS
66      C
67      LINE= IFLAG(KR,IL)      @ LINEAR IF 1 AND NONLINEAR OTHERWISE
68      C
69      C ANNUAL LINE INSTALLATION COST
70      C
71      AN=1.
72      LNKCLN(IL,1)= ANSTLN(KR,IL,KK,IDPX,2)*AN*NDV
73      IF (LIN.NE.1) GO TO 41
74      C
75      C LINEAR LINE RECURRING COST FUNCTION
76      C
77      BN=DST/RECLN(KR,IL,KK,IDPX,1)
78      LNKCLN(IL,2)= RECLN(KR,IL,KK,IDPX,2)*BN*NDV*12.
79      GO TO 32
80      41      CONTINUE
81      C
82      C NONLINEAR LINE RECURRING FUNCTION
83      C
84      DO 10 NON=1,8
85      NON2=2*NON
86      NON1=NON2-1
87      COST=RECLN(KR,IL,KK,IDPX,NON2)
88      DT=RFCRLN(KR,IL,KK,IDPX,NON1)
89      IF (DST.GT.DT) GO TO 51
90      LNKCLN(IL,2)= COST*DST*NDV*12+LNKCLN(IL,2)
91      GO TO 32
92      51      CONTINUE
93      LNKCLN (IL,2)= COST*DT*NDV*12+LNKCLN(IL,2)
94      DST=DST-DT
95      10      CONTINUE
96      32      CONTINUE
97      1      CONTINUE
98      KCHG=1
99      KADD=1
100     RETURN
101     END

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RPRT STACOM.RHOFUN/0777

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5192R*STACOM(1),RHOFUN/0777
1      SUBROUTINE RHOFUN(T1,T2,LINEQU,LNLMT,RHOLIN,RHO)
2      C
3      C *****
4      C CALCULATE LINE UTILIZATION
5      C T1= LINT TO SWITCHED TRAFFIC
6      C T2= SWITCHER TO LINE TRAFFIC
7      C LNLMT= HIGHEST LINE TYPE
8      C LINEQU= LINE CONFIGURATION
9      C
10     C *****
11     PARAMETER NP3=4
12     COMMON/LINCHR/ LINMIX(NP3),LINCAP(NP3),UTTLIZ(NP3)
13     * /CONST/ N1,N2,N3,N4,N7,NCITY
14     * /SUM/ASUM(4),RSUM
15     * /XMT/ TIMXMT(7,NP3),WAIT(6)
16     * /MSLA/ AMSL(7)
17     DIMENSION LINEQU(1),RHOLIN(1)
18     RHO=0.
19     CAP=0.
20     DO 8 N=1,N3
21     CAP=CAP+LINEQU(N)*LINCAP(N)
22     A CONTINUE
23     CN=LINCAP(LNLMT)/CAP @NORMALIZATION FACTOR
24     XSAC1=CN*T2*ASUM(3)/(RSUM*AMSL(5)*A.) @OUTPUT WITH PRIO 1
25     XSAC2=0.
26     IF(AMSL(6) .EQ. 0.) GOTO 1201
27     XSAC2=CN*T2*ASUM(4)/(RSUM*AMSL(6)*A.) @OUTPUT WITH PRIO 2
28     1201 CONTINUE
29     XSAC3=CN*T1/(AMSL(4)*A.) @INPUT TRAFFIC IN TRANS
30     RHOLIN(1)=XSAC1*TIMXMT(5,LNLMT)
31     RHOLIN(2)=XSAC2*TIMXMT(6,LNLMT)
32     RHOLIN(3)=XSAC3*TIMXMT(4,LNLMT)
33     RHO=RHOLIN(1)+RHOLIN(2)+RHOLIN(3)
34     RETURN
35     END

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QPRT STACOM.LINNUM/0777

51928*STACOM(1).LINNUM/0777

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1      SUBROUTINE LINNUM(T1,T2,LINEQU,LNLMT,JFLAG,RHO)
2      C
3      C *****
4      C FIND LINE CONFIGURATION BASED ON THE GIVEN TRAFFIC AND
5      C APPLICABLE LINE TYPE
6      C JFLAG= 1 FOR MULTIDROP LINE CASE
7      C T1= LINE TO SWITCHER TRAFFIC
8      C T2= SWITCHER TO LINE TRAFFIC
9      C
10     C *****
11     C . PARAMETER NP3=4
12     C COMMON/LINCHR/ LINMIX(NP3),LNCAP(NP3),UTILIZ(NP3)
13     C * /CONST/ N1,N2,N3,N4,N7,NCITY
14     C * /MSLA/ AMSL(7)
15     C INTEGER TRAF
16     C DIMENSION LINEQU(1),RHOLIN(3)
17     C TRAF=T1+T2
18     C DO 1 I=1,N3
19     C   LINEQU(I)=0
20     C 1 CONTINUE
21     C LNLMT=0
22     C CALL REFER
23     C LNLMTU=LNLMT
24     C
25     C SET UP INITIAL LINE CONFIGURATION
26     C
27     C IF(JFLAG .EQ. 1) GOTO 10
28     C 3 CONTINUE
29     C LINEQU(LNLMT)=LINEQU(LNLMT)+1
30     C LCAP=LNCAP(LNLMT)*UTILIZ(LNLMT)
31     C IF(TRAF.LT.LCAP) GOTO 7
32     C TRAF=TRAF-LCAP
33     C CALL REFER
34     C GOTO 3
35     C 10 CONTINUE
36     C LINEQU(LNLMT)=TRAF/(LNCAP(LNLMT)*UTILIZ(LNLMT))+1
37     C 7 CONTINUE
38     C 70 CONTINUE
39     C CALL RHOFUN(T1,T2,LINEQU,LNLMTU,RHOLIN,RHO)
40     C IF(RHO .LT. UTILIZ(LNLMT)) GOTO 150
41     C IF(LNLMTU.NE.N3) GOTO 72
42     C IF(JFLAG.NE.1) GOTO 73
43     C LINEQU(N3)=LINEQU(N3)+1  Q NEEDED TO BE MODIFIED
44     C GOTO 70
45     C 73 CONTINUE
46     C DO 2 N=1,N3
47     C   IF(LINEQU(N) .NE. 0) GOTO 20
48     C 2 CONTINUE
49     C 20 CONTINUE
50     C NL=N
51     C IF(NL.EQ.N3) GOTO 74
52     C LINEQU(NL)=0
53     C 22 CONTINUE
54     C NL=NL+1
55     C IF(LINMIX(NL).EQ.0) GOTO 22
56     C LINEQU(NL)=LINEQU(NL)+1

```

```

57      GOTO 70
58      74      CONTINUE
59      LINEQU(1)=1
60      GOTO 70
61      72      CONTINUE
62      LINEQU(LNLMTU)=0
63      LNLMTU=LNLMTU+1
64      IF(LINMIX(LNLMTU).EQ.0) GOTO 72
65      LINEQU(LNLMTU)=1
66      GOTO 70
67      150     CONTINUE
68      LNLMT=LNLMTU
69      RETURN
70      SUBROUTINE REFER
71      C
72      C FIND THE UPPER LIMIT OF LINE TYPE ALLOWED
73      C
74      DO 14 NN=1,N3
75          LTRAF=TRAF/UTILIZ(NN)+0.5
76          IF(LINMIX(NN).EQ.0) GOTO 14
77          LNLMT=NN
78          IF(LTNCAP(NN).GT. LTRAF) GOTO 15
79      14      CONTINUE
80      15      CONTINUE
81      RETURN
82      END

```

OPRT STACOM.PACK/0777

5192R*STACOM(1).PACK/0777

```

1      COMPILER (FLD=ABS)
2      SUBROUTINE PACK(I,K,L,IA)
3          C
4          C *****
5      C RETRIEVE/STORE DATA FROM/INTO ARRAY IA
6      C L=1 FOR STORING AND L=2 FOR RETRIEVAL
7      C K= DISTANCE DATA CONCERNED
8      C
9      C *****
10     DIMENSION IA(1)
11     IQ=(I-1)/4 @THE WORD LOCATION
12     IR=I-IQ*4 @THE QUARTER CONCERNED
13     IQ=IQ+1
14     IS=(IR-1)*9
15     IF(L.EQ.1) GO TO 10
16     C
17     C RETRIEVE IT(9 BITS) BEGINNING AT IS-TH BIT OF THE IQ-TH WORD
18     C
19     K=FLD(IS*9,IA(IQ))
20     RETURN
21     C
22     C STORE IT(9 BITS) BEGINNING AT IS-TH BIT OF THE IQ-TH WORD
23     C
24     10 CONTINUE
25     FLD(IS*9,IA(IQ))=K
26     RETURN
27     END

```

@PRT STACOM.DIST/0777

51928*STACOM(0).NIST/0777

```

1      FUNCTION DIST(I,J)
2      C      *****
3      C
4      C FIND DISTANCE BETWEEN I AND J
5      C
6      C      *****
7      C      PARAMETER NP1=130,NPC=360
8      C      PARAMETER NP6=(NPC*NPC/2-NPC+1)/4+1
9      C      PARAMETER NP7=4
10     C      COMMON /REF/IREF(NPC),TRAFF(NP1,2,NP7),
11     C      *      DSTNCE(NP6),MAPADR(NP1)
12     C      INTEGER DSTNCE
13     C      DIST=0.
14     C      IF(I.EQ.J) RETURN
15     C      II=MAPADR(I)  @ACTUAL CITY INDEX
16     C      JJ=MAPADR(J)
17     C      IF(II.EQ.JJ) RETURN
18     C      IJL=LINK(II,JJ)
19     C      CALL PACK(IJL,IDIST,2,DSTNCE)
20     C      DIST=IDIST
21     C      IF(IDIST.NE.511) RETURN
22     C      DIST=RECOVR(IJL)
23     C      RETURN
24     C      END

```

QPR T L.LINK/0777

51928*STACOM(0).LINK/0777

```

1      FUNCTION LINK(J,K)
2      C
3      C *****
4      C FIND THE RELATIVE LOCATION FOR (J,K) COMBINATION
5      C WHICH IS THEN USED FOR FINDING DISTANCE BETWEEN SYSTEM
6      C TERMINATIONS J AND K
7      C
8      C *****
9      C PARAMETER NP1=130,NPC=360
10     C PARAMETER NP6=(NPC+NPC/2-NPC+1)/4+1
11     C PARAMETER NP7=4,NP3=4
12     C COMMON /CONST/ N1,N2,N3,N4,N7,NCITY
13     1 /REF/IREF(NPC),TRAFD(NP1,2,NP7),DSTNCF(NP6),MAPADR(NP1)
14     C INTEGER DSTNCF
15     C LINK=0
16     C IF(J.GT.NCITY.OR.K.GT.NCITY.OR.K.F0.J) RETURN
17     C JJ=J
18     C KK=K
19     C IF(J.LT.K) GOTO 1
20     C JJ=K
21     C KK=J
22     1 CONTINUE
23     C LINK=(JJ-1)*NCITY + KK - IREF(JJ)
24     C RETURN
25     C END

```

GPRT L.RECOVR/0777

51928*STACOM(0).RECOVR/0777

```

1      FUNCTION RECOVR(I)
2      C      *****
3      C
4      C RETRIEVE OVERFLOW DISTANCE DATA FROM IVRD
5      C
6      C      *****
7      C      PARAMETER NPC=360,NPO=10*NPC
8      C      COMMON /OVER/ IVRD(NPC*2),IOVER1
9      C      DO 10 N=1,IOVER1
10     C      IF(I.EQ. IVRD(N,1)) GOTO 20
11     C      CONTINUE
12     C      WRITE(6,99) I
13     C      99  FORMAT(1X,' NO OVERFLOW DATA HAS BEEN FOUND ',
14     C      *      'FOR LOCAL INDEX',216)
15     C      STOP
16     C      20  CONTINUE
17     C      RECOVR=IVRD(N,2)
18     C      RETURN
19     C      END

```

QPRT L.PLOTPT/0777

51928*STACOM(0).PLOTPT/0777

```

1      SURROUTINE PLOTPT(L1,L3)
2      C      *****
3      C
4      C SUBROUTINE FOR MOVING CALCOMP PEN WITH OR WITHOUT PEN DOWN
5      C      L3=1 FOR MOVING WITH PEN DOWN
6      C      =2 FOR MOVING WITH PEN UP
7      C      =3 FOR CLOSING THE PLOTTING
8      C
9      C      *****
10     PARAMETER NPC=360
11     COMMON/VH/IVERT(NPC),IHORZN(NPC)
12     DIMENSION IBUF(1000)
13     DATA IP/0/ QFLAG FOR PLOTS CALL
14     DATA X/1.2566/
15     IF(IP .NE. 0) GOTO 50
16     CALL PLOTS
17     50    CONTINUE
18     IF(L3 .EQ. 3) GOTO 100 QPLOTTING IS TO BE CLOSED
19     AV=IVERT(L1)
20     AH=IHORZN(L1)
21     BV=AV*COS(X)+AH*SIN(X)
22     BH=AV*SIN(X)-AH*COS(X)
23     BH=(8300.-BH)/301.
24     BV=(8V-5500)/301.
25     IF(L3 .EQ. 2) GOTO 80
26     CALL SYMBOL(BH,BV,0.025,4,0.,-2) QPEN IS DOWN
27     80    CONTINUE
28     CALL PLOT(BH,BV,3) QPEN IS UP
29     IP=1 QPLOTS CALL IS NOT NEEDED ANY MORE
30     RETURN
31     100   CONTINUE
32     CALL PLOT(10.,0.,999)
33     RETURN
34     END

```

QPRT L.RSPNSE/0777

5192R*STACOM(0).RSPNSE/0777

```

1      SUBROUTINE RSPNSE(T1,T2,LINTYP,M,IOK)
2      C      *****
3      C
4      C CALCULATE MEAN RESPONSE TIME FOR THE PROPOSED MULTIDROP LINE
5      C
6      C WAIT(6)=ITEMIZED DELAYS DUE TO
7      C      1=WAIT FOR POLLING      2=WAIT FOR I/O      3=INPUT XMT TIME
8      C      4=CPU TURNAROUND      5=OUTPUT QUEUE WAIT 6=OUTPUT XMT TIME
9      C
10     C      PARAMETER NP3=4
11     C      COMMON/RESP/ RHOLIN(4),RSPTIM
12     C      1 /XMT/ TIMXMT(7,NP3), WAIT(6)
13     C      2 /BOUND/ NTERMS,TIMREQ,MPROC,MPLT
14     C      3 /CONST/N1,N2,N3,N4,N7,NPCITY
15     C      DIMENSION LDUMMY(NP3)
16     C      DO 10 N=1,N3
17     C          LDUMMY(N)=0
18     C      10 CONTINUE
19     C      LDUMMY(LINTYP)=1
20     C      IOK=0
21     C
22     C      CALL RHOFUN(T1,T2,LDUMMY,LINTYP,RHOLIN,PHO)
23     C      RHOLIN(4)=1.-RHO
24     C      IF(RHOLIN(4) .LE. 0.) RETURN
25     C      WAIT(1)=(TIMXMT(1,LINTYP)+TIMXMT(2,LINTYP))*(M-1)/2
26     C      WAIT(2)=(1.-RHOLIN(4))*TIMXMT(7,LINTYP)/((1-RHOLIN(1))-
27     C      1 RHOLIN(2))*RHOLIN(4))
28     C      WAIT(3)=TIMXMT(3,LINTYP)
29     C      WAIT(5)=(1.-RHOLIN(4))*TIMXMT(7,LINTYP)/(1-RHOLIN(1))
30     C      WAIT(6)=TIMXMT(5,LINTYP)
31     C      RSPTIM=0.
32     C      DO 11 J=1,6
33     C          RSPTIM=WAIT(J)+RSPTIM
34     C      11 CONTINUE
35     C      IF(RSPTIM .GT. TIMREQ) RETURN
36     C      IOK=1      RESPONSE TIME CRITERION IS SATISFIED
37     C      RETURN
38     C      END

```

QPRT L.INPUT/0777

APPENDIX B

GLOSSARY

AT&T	American Telephone and Telegraph Company
@RUN, etc.	Control statements under EXEC 8 system (of the UNIVAC computer system)
BPS	Bits per second
CalComp	CALifornia COMputer Products
Central Link	The direct link between a computer and a remote terminal
Centroid	The geographical center of a set of system terminations
Communication Network	A network with several terminals connected by a set of communication channels
Communication Protocol	The system used for performing interfacing (hand-shaking) between a computer and a remote terminal
CPU	Central Processing Unit
Data Base	A collection of cross-referenced set of files which allows systematic data filing and retrieval by a digital computer
D Bank	Storage area for data under EXEC-8 system of the UNIVAC Computer System.
Drop	A chargeable item associated with each terminal on a multidrop line
EXEC-8	UNIVAC 1100 series executive system
FORTRAN	FORMula TRANslator
FORTRAN V	A FORTRAN type of high level language which is only applicable in UNIVAC computers
I Bank	Storage area for program instructions under EXEC 8 system of the UNIVAC Computer System
ID	Identification
Line Utilization	The ratio of traffic on a line to the line capacity

MPL	Multischedule Private Line, one of the interstate tariffs used by AT&T
Multidrop Line	A communication line which has more than one terminal and is connected to a data processing system
Multidrop Network	A communication network where one or more lines are multidrop lines
PUNCH\$, etc.	System designated file name for punch card output, etc.
Regional Network	A network which connects all terminals in a given region
Regional Switching Center (RSC)	A regional data processing center which is used to provide the message switching capability for all terminals in the region
STACOM	STate Criminal Justice COMMunication Project
Star Network	A communication network where each system termination is directly connected to the central data processing system
SUP-Time	A run time estimate by the EXEC-8 accounting subsystem which accounts for the amount of time spent by a run on usage of CPU, I/O processing and execution of system control statements and executive requests
System Termination	A logical node in the communication system under the STACOM program, which consists of one or more physical terminals
TELPAC	A specific tariff for a telecommunication network
Terminal	A device that allows users of a data processing system to gain access to that system in a more convenient manner than the input/ output devices local to that system
Terminal Response Time	The duration from the time a user initiates a request for network service at the terminal to the time he receives a complete response
Tree	A graph which has a root node without any predecessors and other nodes have unique predecessors

UNIVAC

UNIVersal Automatic Computer, a computer
trade name by Sperry Rand Corporation

Vertical Horizontal (V-H)
Coordinates

A pair of numbers which are designated by
AT&T for cities and used for the purpose of
calculating distance between any two cities